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MANAGING THE CENTRAL ARTERY/TUNNEL PROJECT:

An Exploration of Potential Cost Savings

July 1997

University of Massachusetts Boston

The McCormack Institute

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MANAGING THE CENTRAL ARTERY/TUNNEL PROJECT:
An Exploration of Potential Cost Savings

Submitted to the Commonwealth of Massachusetts

Senate Committee on Ways and Means
House Committee on Ways and Means
The Joint Committee on Transportation of the House and Senate

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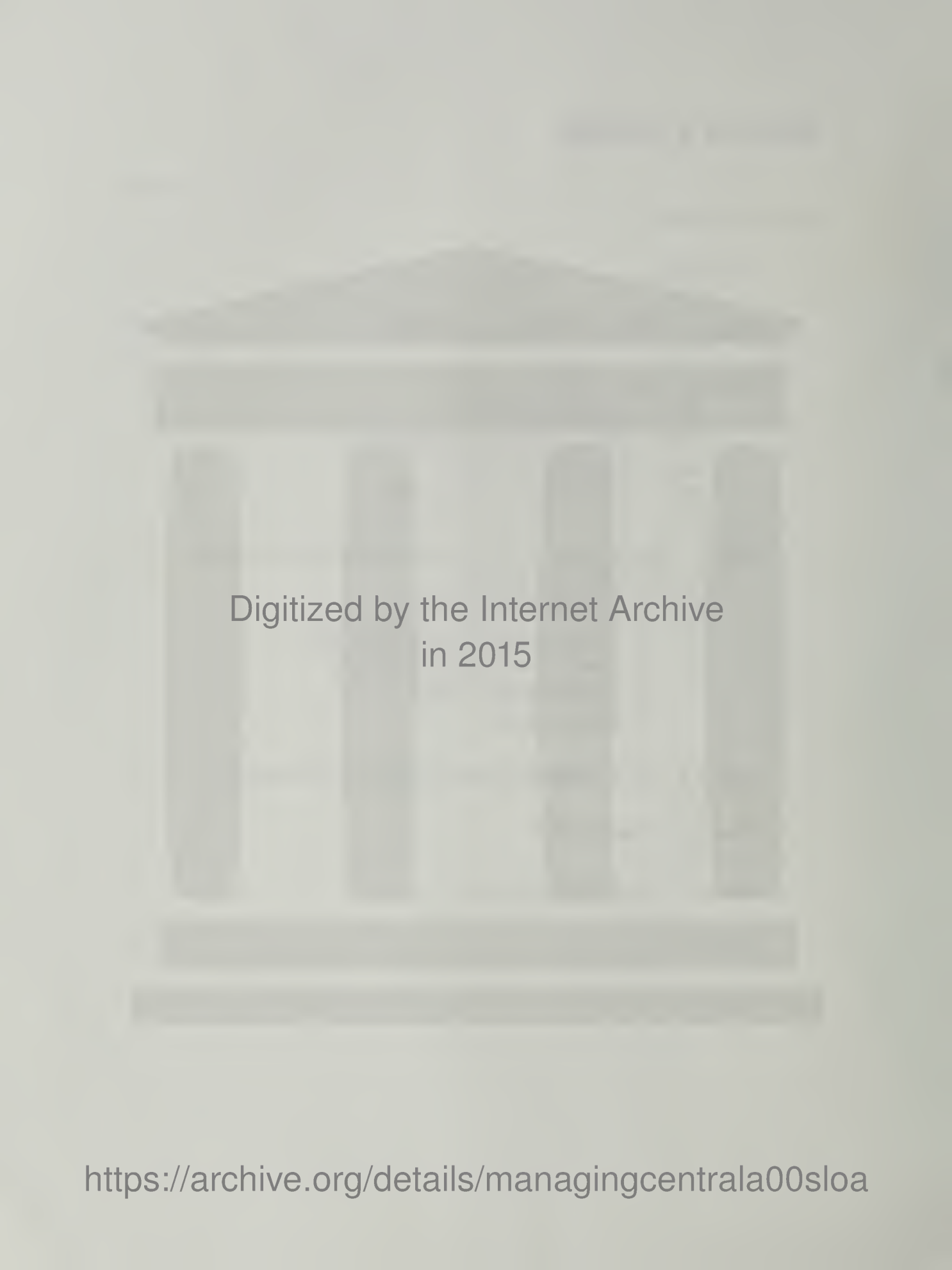
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EXECUTIVE SUMMARY

In 1996, under Chapter 205 of the 1996 Acts and Resolves, the Massachusetts Legislature authorized the McCormack Institute of Public Affairs at the University of Massachusetts Boston to "review and explore possible cost savings within the Central Artery/Third Harbor Tunnel project" and to report its findings to the House and Senate Committees on Ways and Means and the Joint Committee on Transportation. For this study, the Institute assembled an interdisciplinary team from within its own ranks and outside, first, to examine the composition and rationale for the project's estimated cost of $10.4+ billion and, second, to identify possible cost savings within this budget. This report describes the findings, conclusions and recommendations of this effort. Our major findings are summarized below:

1. The sizeable cost to design and build these seven miles of Interstate roadways in and adjacent to Downtown Boston is attributable to three major factors;

- The extensive tunneling and complicated interchanges required to rebuild and extend the express highway system through the center of an active and vibrant metropolitan region. This has required the design and execution of 119 interlinked construction contracts in eight different construction zones, each densely developed and heavily used.

- The need for the design and construction to not only make long term improvements to the urban and natural environment mandated by law but also to take measures to insure the on-going operations of the city during the construction process. This is reflected in 1500 separate mitigation agreements developed during the course of project planning and design.

- The time -- over two decades -- needed to undertake engineering and design work, mitigation agreements and construction and the impact of inflation.

While there is no precise way to allocate the costs to these three factors, we estimate that about 30% to 35% of the cost can be attributed to the required tunneling and interchange construction alone, about 25% to 30% to the measures needed to mitigate the impacts of the construction and meet required environmental standards, and up to 40% to account for inflation and cost escalation resulting from a 25 year design and construction period.

2. Of the total budget, over two thirds has been either spent or committed. The engineering design is virtually complete, and construction on all the major components is well underway. Reductions in the scope of the project or major changes in mitigation agreements at this stage would be difficult and would create many unacceptable consequences for the city and region.

3. To achieve budget reductions in the scale of 2% to 4%, that is, $250 to $450 million, the

project would have to rely principally on measures to avoid all delays and unanticipated changes in planned scope for all remaining construction packages, plus good luck in completing packages on the critical path on or ahead of schedule. Keeping all elements of the project on schedule is critical to cost control and containment. So far, the project has been remarkably free of contractor litigation which has been key to maintaining the schedule.

4. To date, the challenges of managing the complicated engineering design and difficult construction process have been met by the CA/T project management team. However, there are already upward cost pressures as the tunneling operations in downtown Boston move ahead. The continued diligent application of the cost control and containment measures already in place will be required to keep the budget within existing targets. There are a whole battery of such measures which require extensive cooperation among all the "parties at interest," not only the project management and the contractors, but the Legislature, other state regulatory agencies, and local communities as well. These measures fall into two major areas:

- In operating the construction program, now well underway.

- In downsizing and transferring functions from the management team of the Joint Venture contractor, who has carried the burden of managing the design and construction process to date, to the permanent agencies responsible for the ultimate operation of the system -- the Massachusetts Highway Department and the Massachusetts Turnpike Authority.

5. Most of the key measures involve the management of the contract bidding and administration process within the domain of the project management. However, there are some measures which require legislative action or interagency cooperation to avoid unnecessary costs (See Table 1). These include:

- Changes in the laws governing the bidding process, particularly exemptions from filed sub-bid requirements, and experimenting with A-B bidding procedures.

- Changes in other legislatively mandated requirements, (use of police details, for example).

- Relief from redundant environmental review requirements and assistance of other state and local agencies in dealing with soil and landfill issues.

6. The still unformulated changes in the program for federal government funding of highway construction are not likely to provide the same high level of federal participation in the CA/T program as in the past. This means higher levels of state resources may be needed to complete the job. The passage of the transportation bond bill and the legislation creating the Metropolitan Highway System were essential to keep the project on track. The current favorable environment

for state borrowing and the use of Grant Anticipation Notes should ease the burden of this increase on overall state finances. However, there is a need to address the policy issues involving revenue generation -- tolls, user fees, gas taxes, and others -- as the CA/T system is put into operation.

7. There are a substantial number of benefits and beneficiaries that will result from the CA/T project. However, there are two categories of beneficiaries who will benefit more than the rest. These are:

- The direct users of the system, particularly the downtown-bound and airport-bound users of I-90 and I-93 links when completed.

- The owners of property, particularly in the downtown Boston and South Boston waterfront industrial area, who will have access to their land extensively enhanced at the expense of the Commonwealth.

The Commonwealth must examine the ways through which these beneficiaries can contribute their fair share to the on-going costs of the CA/T program, including the substantial debt service the Commonwealth and its agencies will incur.

8. As the CA/T program continues in its major construction phase, there are two important areas in which the Legislature can and should play a role:

- Monitoring the changes in the cost and budget allocations to anticipate problems which may require legislative action in the future.

- Addressing the issues of cost recovery, including user charges, returns on land value enhancements, and others.

The following is a summary of the principal findings, conclusions and recommendations in the six chapters which comprise the body of this report.

Chapter 1 -- The history and evolution of CA/T costs

- The size of the budget is dictated by two interrelated factors: first, the decision to finish the region's interstate highway system by rebuilding and extending it in the heart of the regional center and, second, to undertake the construction with full weight given to the needs and concerns of affected parties -- the business and residential communities and the natural environment.

- The increases over the initial estimates are due to scope changes essential to mitigate the construction impacts, plus inflation and the escalation of estimated cost over two decades.

- The controversies involving the most difficult program elements (Central Artery North Area and the Fort Point Channel crossings) were costly in both money and time.

Chapter 2 -- The current budget

- The budget of $10.4+ billion estimated in the Finance Plan could, in fact, be closer to $10.7 to $11.0 billion. The pressure on the budget is upward, in part as a result of mitigation measures required to control noise and dust and to maintain traffic flow in downtown Boston .

- Over 25% of the budget has been allocated to engineering design and management and most of it is already spent. No major redesign is possible without severe difficulty.

- Most of the budget allocated for actual construction will be committed by the end of 1998. Actual construction is proceeding on all the key components of the program.

- Close to half of the construction budget is allocated to two critical areas -- the northern section of the Artery and the I-93 /I-90 Interchange. Both are complicated because of the difficult engineering and mitigation challenges involved.

- Mitigation measures -- both permanent and temporary -- are a major portion of the budget and have been required to both obtain legal approvals and maintain public and political support for the program.

- At this stage of advancement, changes in project scope in order to reduce budgeted costs are not possible without severe damage or delay to the program and its outcome. Many would have the effect of dumping more traffic onto local streets in the areas through which the project is being built.

Chapter 3 -- Cost containment/reduction in the construction process

- At this stage, interactions between project management and the construction contractors provide the major arena for cost savings. Keeping the construction program on schedule is the key.

- The range of potential savings is narrow. The program needs strong management and good luck to keep within a 2% to 4% reduction range.

- There are measures identified by both contractors and management which can help to

contain and reduce costs. These are primarily in the area of contract administration -- bid policy, partnering policy, change order policy, the Value Engineering Change Proposals (VECP) program, and others.

- There are also some legislative actions and interagency cooperative agreements which can help -- filed sub-bid relief, new bidding methods, environmental assistance, etc.

- Appropriate legislative committees need to maintain vigilance over the program.

Chapter 4 -- Cost containment/reduction in project management

- The costs to design and manage the project have been great -- a function of the time and engineering detail required to satisfy all the difficult program requirements.

- As the construction process moves ahead, ways should be found to relieve the costs of project management by reducing the staff now on the payroll of the Joint Venture.

- There are two possible methods for achieving this: first, by switching some functions to the permanent agencies (Massachusetts Turnpike Authority and Massachusetts Highway Department) as they become geared up to manage the metropolitan highway system; and second, by reducing overlapping functions in the project management team.

Chapter 5 -- Financing CA/T

- Changes in the federal funding formula for highway support and its uncertain future may put pressure on the Commonwealth to come up with more financial support for the CA/T project than was anticipated at the outset.

- The state transportation bond and Metropolitan Highway System legislation both provide needed resources essential to completing the CA/T program. The current low interest fiscal environment should help lessen the unfavorable impact of such large state borrowing on the overall budget of the Commonwealth.

- The advent of the Massachusetts Turnpike Authority (MTA) as the key operator of the completed CA/T system offers opportunities for sound policies and programs to generate user revenues. These will be needed to help repay the debt.

- The use of Grant Anticipations Notes (GANS) will help to bridge the period of cash flow or obligations deficit between 1998 and 2001.

- The new bond legislation permits project construction to move quickly and locks current low interest rates into construction borrowing.

Chapter 6 -- Benefits and beneficiaries

- When completed, the project will produce many benefits for the region including improved traffic flow in the regional center, new environmental amenities, and new opportunities for economic development.

- However, some will receive benefits greater than most. Two categories stand out: first, the highway travelers heading to and through downtown Boston and Logan Airport; second, the owners and users of property in downtown Boston and the industrial areas of South Boston.

- The issues of future public policy arising from the CA/T project should focus on how and in what form these beneficiaries should help pay their fair share of the costs of the program. There is time to work out the issues involved, which should be placed high on the regional agenda.

Table 1. --SUMMARY OF CA/T COST CONTAINMENT/REDUCTION MEASURES

	INVOLVING CA/T MANAGEMENT POLICIES	REQUIRING LEGISLATIVE SUPPORT	REQUIRING INTERAGENCY COOPERATION
IN THE CONSTRUCTION PROCESS			
Contract bidding procedure	**Expanding the contractor bidding pool** Bid acceptance policy	A-B bidding procedure **Filed sub-bid exemption**	
Contract administration	**Partnering policy** **Change order policy** **VECP policy**	**A "deductible" for change orders**	
Environmental regulatory assistance			**Additional landfill sites** Relief from unneeded reviews Revised soil quality definitions
Other Measures	**Wrap-around insurance program**	Requirements for police details Approving vertical construction plans and specs	
IN PROJECT MANAGEMENT			
Duplication of functions **Community relations activities** **Non-essential functions**	**Transfer of permanent functions now carried out by Joint Venture to MHD and MTA**		Rationalization of CA/T related fiscal affairs, interagency coordination and community relations within EOTC agencies.

Note: **Bold** denotes measures of potential major impact on future costs and/or requiring priority attention and monitoring.

AN EXPLORATION OF POTENTIAL COST SAVINGS FOR THE CENTRAL ARTERY/TUNNEL PROJECT

INTRODUCTION

The John W. McCormack Institute of Public Affairs at the University of Massachusetts Boston is an institution whose primary mission is public service. Through public policy research, educational programs, policy practice and the dissemination of knowledge, the Institute seeks to have a constructive impact on policy formulation, problem solving and public discourse concerning urgent civic challenges facing state and local government in the New England region.

In 1996, under Chapter 205 of the 1996 Acts and Resolves, the Massachusetts legislature authorized the Institute to undertake a study **"to review and explore possible cost savings within the Central Artery/Third Harbor Tunnel project"** and report its findings to the House and Senate Committees on Ways and Means and the Joint Committee on Transportation.

In devising the scope of study, our focus has been on analyzing costs of the project through the prism of good public policy -- that is, to identify the interests of the Commonwealth, as the ultimate owner of the project, in its size and scope, current status, and expected outcomes. Our team consisted of experienced public policy analysts recruited from within the ranks of the Institute and outside. It included experts on engineering and construction industry practices in the Commonwealth, but with no past or current involvement in the CA/T program.

With this focus and objective, we did not play the role of a financial auditor or an evaluator of the engineering designs. We did not play the role of an in-depth evaluator of management practices as would an outside management expert. Nor did we attempt to duplicate the legally mandated reviews of the numerous federal and state agencies with continuing responsibly for project oversight. Our role, then, has been that of a neutral broker.

The starting point for this review was the cost estimates contained in the Massachusetts Highway Department Finance Plan for the Central Artery/Tunnel Project, dated September 30, 1996, which estimated the overall cost of the project at **$10.4+ billion when completed. $4.9 billion has been spent as of June 30, 1996.**

Already Spent to 6/30/96			Needed to Complete		
Construction	$2.4 billion	(49%)	Construction	$4.8 billion	(87%)
Management	$1.3 billion	(27%)	Management	$0.505 billion	(9%)
Engineering Design	$0.8 billion	(16%)	Engineering Design	$0.179 billion	(3%)
Right of Way	$0.4 billion	(8%)	Right of Way	$ 0.45 billion	(1%)
Totals	$4.9 billion	(100%)	Totals	$5.5 billion	(100%)

Our first major task was to determine the basis for these project costs by reviewing the elements that make up this sum. These elements include the complicated construction required for the extensive tunneling and intersection design, the long term and short term mitigation measures needed, the relocation of utilities, the scheduling of the various program elements, the management costs associated with an extensive and lengthy design and construction process, and the benefits associated with each.

Our next task was to examine the question of whether any costs could be reduced or eliminated and what the impacts of such actions would be. For this analysis, we reviewed four principal areas in which there is significant budget allocated for project completion or important implications for how the project can be completed. The four areas are:

- Proposals for potential **scope reductions** (as identified in the Finance Plan)
- The **construction process,** to identify possible cost saving and containment measures
- Possible savings in **program management costs**
- The **funding status** of the project

To undertake these reviews, the study team examined the extensive documentation generated in the course of the program by project management, oversight agencies, the press, and others. This documentation included the monthly management reports prepared by project management to track progress on all phases of the program. We also attended a number of legislative hearings, meetings, seminars, and conferences where issues related to the project have been discussed and debated. In addition, we interviewed scores of people who have played an important role in formulating or carrying out the project, including both those supportive and those critical. Among those interviewed were the project management staff, former officials of state transportation agencies, Federal Highway Administration (FHWA), Government Accounting Office (GAO), Massachusetts Highway Department (MHD), the Massachusetts Department of Finance and Administration, the Inspector General's staff and other agency staff; engineers, construction contractors and other consultants associated with the project, representatives of community and environmental groups, and others. To respect the confidentiality and candor of these contacts, we have made no attempt to attribute specific remarks and attitudes to any of those interviewed. We have listened carefully to a variety of views and opinions, but this report reflects exclusively the findings, conclusions, and recommendations of the study team.

The following report summarizes the findings, conclusions and recommendations of this review. The results are contained in six chapters and an appendix containing cost information on the project:

Chapter 1 -- The history and evolution of CA/T costs
Chapter 2 -- The current budget
Chapter 3 -- Cost containment/reduction in the construction process
Chapter 4 -- Cost containment/reduction in project management
Chapter 5 -- Financing
Chapter 6 -- The benefits and beneficiaries

CHAPTER 1 -- THE HISTORY AND EVOLUTION OF CA/T COSTS

To understand the basis for the costs of the Central Artery/Tunnel project, one must first understand three important aspects of the undertaking: the physical and environmental setting of the project, the decision-making process that led to its parameters, and the expected product and results of the investment.

The physical and environmental setting

The project involves the building of two major express highway links in the center of the Boston metropolitan region, first an extension of the Massachusetts Turnpike (Interstate Route 90) across Boston Harbor to Logan International Airport and, second, the rebuilding in an underground tunnel system of the existing elevated Central Artery (Interstate Route 93) which runs north and south through Downtown Boston. To a large extent, these two highway links augment a system of hub and spoke expressways conceived after World War II and designed to provide major highway capacity in the center of the region and relieve the older urban arteries that became overburdened with the growth of post-war traffic.

The urban environment in which this construction is taking place, however, is one of the most difficult for any highway system built in the nation. Downtown Boston is a densely packed business, governmental, financial, cultural and tourism center. As the locus for over 300,000 jobs, it is the largest economic center in New England. This historic center is surrounded by water -- Boston Harbor and the numerous rivers feeding into it. Across the Harbor on an isolated peninsula is the New England region's major airport, which has emerged as one of the important pieces of infrastructure supporting the great high tech, financial, health and educational enterprises that characterize the region's modern economy.

Both the land and water environments in and around the regional center are sensitive, and major investments have been and are being made to preserve both. The neighborhoods surrounding downtown Boston are active places providing the sites for many of the nation's most important educational and cultural institutions, along with highly prized housing resources for a diverse urban population. This is in contrast to many American cities where the abandonment of neighborhoods adjacent to central business districts made it relatively easy to build express highways around the downtown perimeter. Boston's physical and environmental structure has forced the planning for transportation improvements in the region into a uniquely limited framework.

In the period after World War II, the region's planning authorities developed a long range plan for highways which called for eight radial expressways to center on downtown Boston, along with three circumferential expressways -- an outer belt (now route 495), a middle belt (now route 128 -I-95) and an inner belt to be built through the densely packed communities close to downtown.[1] In the late 1950s

[1] This plan was first proposed in 1948 and adopted by the State Department of Public Works (now MHD) and reaffirmed in subsequent plans. Some but not all of these roads were to be part of the Federal Interstate Highway system, first proposed in 1944, but lacked funding until the passage of the Interstate Highway and

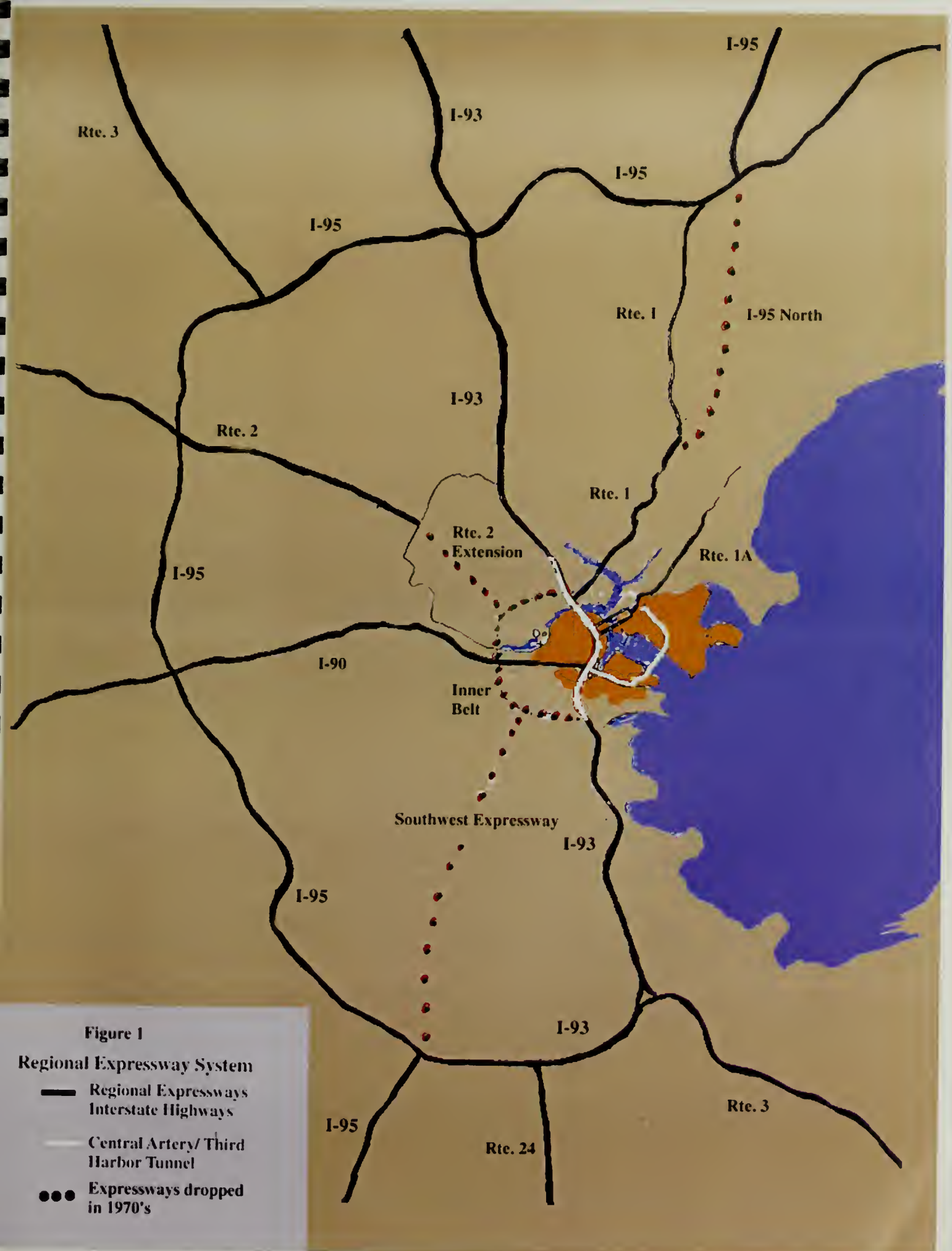

Figure 1

Regional Expressway System

- Regional Expressways
  Interstate Highways
- Central Artery/ Third
  Harbor Tunnel
- Expressways dropped
  in 1970's

and 1960s when the federal government's Interstate Highway program held out the promise for major help to states and metropolitan regions in funding their plans for new highway infrastructure, the Boston region's response was to start to build its planned circumferential and radial expressways (regional map, Figure 1). The initial projects included upgrading Route 128 and building a new outer circumferential (Route I-495) to provide for traffic movement around the region and construction of some of the eight radial expressways to center on downtown Boston. In the 1950's and 1960's three of these radial expressways were built, along with the Central Artery: the Southeast Expressway (Route 3 south) , the Mass. Turnpike (I-90) first to Route 128 in the 1950's then its extension from 128 to downtown in the 1960's , and I-93 North, along with the rebuilding of Route 2 from Route 128 to Alewife. One of the radials, Route 3 north, was built only to Route 128, with its extension to downtown Boston dropped as a result of mounting pressure from the affected communities. The amount of housing and parkland takings and community disruption required to complete the radials from Route 128 towards downtown were causing substantial protests from the impacted communities. In addition, the plan to build a third tunnel across Boston Harbor from downtown to Logan Airport was also running into opposition from affected neighborhood groups in East Boston.

By 1970, plans were still underway to complete the system, the new Southwest Expressway (I-95S) was to be built adjacent to the major railroad connecting Boston to the south and plans were in the works for a new Northeast Expressway (I-95N) generally paralleling Route 1 North, along with the extension of the Route 2 expressway, which had been built from Route 128 to Alewife. All these radials would be connected near the center of the region by the Inner Belt Expressway (I-695), traversing the old established community of Somerville, bisecting the City of Cambridge, crossing the Charles River in the vicinity of Boston University and the Back Bay hospital complexes and the northern sections of Roxbury, and connecting to the Southeast Expressway near the South End. As plans for these major additions came closer to implementation, the affected communities began to object more strongly and question the value of the whole expressway scheme.

The decision making process

In the early 1970's, in response to mounting community pressure, a moratorium on new express highway construction inside Route 128 was declared by then-Governor Sargent. The landmark Boston Transportation Planning Review was initiated to review all the plans and examine the options for each of the radial highway corridors, including improved public transportation. By the end of this review, the decision was made by the Sargent administration not to complete the original plan for the three additional interstate standard expressways to be interconnected by the inner belt highway. This set in motion a whole new strategy for improving the regional transportation system. First, it was decided to put the immediate priority for regional transportation improvements on rebuilding and expanding the existing rapid transit system in the corridors previously considered for the expressways, including extensions to the system to intersect the highway network at strategic points (Alewife and Braintree). It was further decided to revive and improve the region's substandard commuter rail services, which had deteriorated extensively under private ownership. This program of transit improvements was the focus

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Defense Act of 1956 which created the Highway Trust Fund to be financed through federal gas taxes.

for construction activities through the remainder of the decade. To build these transit improvements, federal funds available for Interstate highway construction were "traded in" as provided under revised provisions of federal law.[2]

Second, to meet the state's opportunity and obligation to complete the planned federal Interstate highway system in the region, it was decided to interconnect Interstate 95 through the region by routing it on the existing Route 128 around Boston and adjacent communities to the West, instead of building Interstate 95 on new expressways in the Southwest corridor and in the Route 1-North Shore corridor as a radial connection. This left two major highway system improvements within route 128 on the regional agenda; the first was a third harbor tunnel to the Airport and the second was the rebuilding of the elevated portions of the Central Artery below grade, to complete the I-93 radial system by connecting its northern section with the Southeast Expressway through downtown. **Since the inner belt had been eliminated, the Artery corridor was the only route available to handle the growing volumes of traffic moving through the center of the region. The elevated structure was becoming obsolete and was an eyesore. Rebuilding it underground would not require the kind of land taking that the inner belt would have involved.**

For the rest of the decade of the 1970's, transit improvements were the prime focus for investments in the region's transportation infrastructure. Various succeeding administrations favored either the Artery or the Third Harbor Tunnel project as the next highway priority.[3] These two concepts for highway improvements remained on the table, but there was no consensus on whether to proceed. Finally, in 1983, during the second Dukakis administration, it was decided to combine the two projects into a single program. This would involve **depressing and widening the Central Artery, building the new tunnel to Logan Airport in a new alignment completely on airport property on the eastern end, and connecting the two through the South Boston waterfront on a new seaport access road.** The plan would provide much needed improvement for traffic headed to the airport from the West and the north shore but with much less disruption to the East Boston neighborhood than the earlier scheme. It would further provide badly needed highway capacity to move traffic to and through downtown.

The improvements were eligible for funding under the federal interstate construction program, which would cover 90% of eligible project costs. The tunnel and access road were the logical extension of Interstate 90 from the end of the Massachusetts Turnpike at the intersection of the Southeast expressway to the airport and north. The Central Artery reconstruction would link the two sections of Interstate 93.[4]

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[2] Massachusetts policy makers were a major part of the coalition lobbying Congress for these revisions in the use of Interstate Highway funds.

[3] For a complete discussion of the history and controversies involved in the creation of the Central Artery/Tunnel project, see MEGA-PROJECT - A Political History of Boston's Multi billion Dollar Artery/Tunnel Project, by David Luberoff and Alan Altshuler -- April, 1996 published by the Alfred Taubman Center for State and Local Government - John F. Kennedy School of Government, Harvard University.

[4] There were extensive controversies between the State and Federal administrations about the merits of the new scheme and its eligibility for federal funding under the Interstate program. While the I-90 extension to the airport was considered justified, the more expensive I-93 Central Artery depression was considered by some to be more of an urban beautification than a highway project. The state officials agreed to a compromise under which most, but not all, of the artery costs would be covered by the Interstate program. This policy was adopted in the 1987 surface transportation act which became the basis for project funding. (See Luberoff and Altshuler -- Chapter III)

The decision to depress and widen the Artery and to extend the Turnpike across the Fort Point Channel to connect to the new tunnel required **extensive tunneling in difficult, fully developed urban terrain.** The tunneling, moreover, could not disrupt the businesses and residential neighborhoods of downtown Boston during what would be a long and difficult construction process. Achieving these goals would **require delicate and sensitive construction methods which would be costly.**

With the federal funding in place, the state turned to the detailed planning needed to secure the environmental and other permits required by both state and federal law. During this process, community and environmental interests had to be satisfied, not only that the project would not harm interests but also that it would advance them. The downtown business community had to be assured that the city could continue to function during construction and that the project would be a positive contribution to both traffic flow and urban amenities when completed. Throughout this process, state officials studied dozens of solutions to pressing problems. By 1991, when the Weld administration took office, the process for receiving formal approvals from both the Federal Highway Administration and state environmental regulators was well advanced.

Through this decision making process, the fundamental commitments to build and fund the project were agreed to by Massachusetts policy makers over the last three decades, and endorsed by subsequent administrations, legislatures, and the federal government.

The expected results

As a result of this series of decisions made over an extended period and participated in by state, city and federal government officials with the participation of the local business, environmental and residential communities, the Central Artery/Tunnel project came to resemble **not just the traditional urban highway construction project but something much more. Through the use of the highway construction process, major improvements would be made to the whole urban environment of the region's center**. The Central Artery, one of the nation's most congested highways carrying over 190,000 vehicles a day on a structure designed for 90,000, would be rebuilt and depressed. When expanded and put underground the rebuilt highway would not only improve traffic access to and through downtown Boston but would open up the surface to extensive environmental improvements, particularly in the historic North End neighborhood and in adjacent valuable waterfront locations. Connecting the Mass Turnpike directly to Logan Airport would not only greatly improve the transport access to this key regional facility but also provide access to a large area of under- developed urban land sandwiched between downtown and the airport along the South Boston waterfront. These enhancements would help additional development and improvement of both of these areas.

When one examines the scope and nature of this scheme, one finds that it goes far beyond the characteristics of conventional urban highway construction. It appears to have more in common with major urban surgery -- the equivalent of an arterial bypass operation applied to a functioning urban patient, requiring the skill and sensitivity akin to that of a highly competent medical team, in addition to highly creative highway design, engineering, and construction. This surgery would be performed in front of a very large audience of oversight agencies, government officials and agency heads, anxious

community groups, the press and the general public. This has provided the basis for the costs of the entire program, currently estimated to be $10.4+ billion, to complete the surgery successfully.

The evolution of project costs

While the detailed planning, environmental reviews and negotiations with interest groups in the period from 1985 to 1993 were necessary to move the project through the rigorous permitting process while maintaining political and community support, they also drove up the total costs.

Table 1.1 - History of Project Cost Estimates
(in millions)

Year	*Estimate*	*Exclusions*	*Changes*	*Inflation*	*Projected Cost*
1985	*2,564.0*	-	-	-	*2,564.0*
1987	*3,185.0*		*46.0*	*565.0*	*3,175.0*
1989	*4,436.0*		*799.0*	*462.0*	*4,446.0*
1991	*5,193.0*		*299.0*	*458.0*	*5,193.0*
1992	*6,443.0*		*609.0*	*641.0*	*6,443.0*
1993	*7,740.0*		*869.0*	*428.0*	*7,740.0*
1995	*7,740.0*	*998.0*	*259.0*	*1387.0*	*10,384.0*
Total			*2,881.0*	*3,941.0*	
1996	*10,400.0*				*10,400.0*

Before the detailed planning and engineering began on the project in 1985, the early studies estimated the cost to be **$ 2,564 billion.** This was the figure used by Massachusetts officials responsible for developing the project to obtain the required backing of the federal government, which was expected to fund most of the costs through the Interstate Highway Program. The figure was based on estimated 1982 construction prices and did not include the cost of inflation. Once the project had received the approval to move ahead and the environmental and design studies begun, its scope began to take its full shape, with the active participation of the variety of community and environmental interest groups with important stakes in the outcome. In this phase, a variety of critical issues emerged involving not only the design of the highway segments and their method of construction but also the impact of the construction on the affected communities and on the overall environment.

In this period, there were also fundamental issues raised about the cost of the project and its impact on the allocation of transportation funding resources, including public transit improvements and highway projects in other areas of the Commonwealth. These issues, ranging from the very detailed to those involving fundamental development policy, had to be worked out in order for the project to move ahead. By 1988, when the preliminary detailed engineering design was begun, a number of serious issues involving not only the design, engineering, and construction, but also the allocation of transportation resources were still on the agenda of the policy makers with unresolved controversies still in the wind. By 1992, after the engineering design was well underway and the construction process had begun, the cost was estimated at **$7.74 billion**. In 1996, after most of the final engineering designs had been completed, along with about one quarter of the construction (principally the Ted Williams Tunnel) , the total cost was estimated at **$10.4** billion, with **$4.9** billion having been spent and **$5.5** billion needed to complete the program by 2005.

There are four main reasons for this escalation in estimated cost over this almost 15-year period of design, engineering and conflict resolution. The first is the expansion of basic scope over time; second, the extension of the schedule of completion; third, the changes needed to resolve fundamental conflicts in the design and to meet required transportation and environmental standards and agreed upon mitigation measures; and fourth, the effects of inflation. This cost evolution is described in Table 1-1.

The increases in the scope of the project beyond the initial plan included:

Between 1985 and 1989:

- construction of the haul road through South Boston.
- extension of the southerly portion of the project from the South Bay to the Mass. Avenue interchange.
- addition of high occupancy vehicle (HOV) lanes to the I-90 segments of the project.
- addition of a new intersection connecting the airport interchange to Route 1A in East Boston.

Between 1989 and 1991:

- reconstruction of the northbound tunnel under Dewey Square.
- addition of tunnel covers over I-90 in South Boston.
- adoption of "scheme Z" for the Charles River crossing and the addition of the tunnel connectors to the project under City Square in Charlestown.

Between 1991 and 1992:

- addition of a number of public transit improvements and utility relocation projects to the Central Artery and South Bay interchange areas.
- redesign of the Tunnel under the Fort Point Channel
- taking of additional land required as a result of court judgments.
- redesign of the Charles River crossing plans, scrapping "scheme Z".

These scope additions and changes were the result of extensive bargaining and negotiation between the project designers and the affected "parties at interest," including community, business and environmental groups, the Federal Highway Administration, and a variety of state agencies, with sometimes very difficult issues to resolve.[5]

It should be pointed out that probably the most serious problems affecting both the engineering design and the overall project schedule and related costs were the disputes over the best plan for the Charles River crossing and the best system to cross under the Fort Point Channel, two of the more complicated design and construction elements in the entire scheme. Resolution of these major issues delayed the completion of final designs and slowed the potential to meet the original project construction schedule,

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[5] See Luberoff and Altshuler, op.cit.

increasing the time and the cost of both the design and project management budgets. In 1991, before these issues were resolved, the estimated time to complete the entire project was 1998. By 1993, when the issues were settled enough to let final design and construction proceed, the estimated time for final completion of all construction slipped to 2004.[6]

It should also be pointed out that the "funding environment" under which the planning, design, and engineering of this complicated project was being conducted anticipated that the financial resources of the Interstate Construction Program could be used in most aspects of the project. **Thus the emphasis was put on insuring that the program could pass environmental muster and that there was no basis for the environmental critics to challenge the program in the courts. Cost containment was not the focus of attention during this period.**

However, with the passage of Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991, which provided increased funding for states to complete their interstate highway projects to reflect the effects of inflation, there was an important change in federal policy. The commitment to pay the "costs-to-complete" of unfinished Interstate project was ended. The last official estimates of costs were used to determine the total amount of Interstate Construction Fund financing that eligible projects would receive. Any costs over and above these last official estimates would be funded on a different basis than had been used in the past (The implications of this change on the CA/T project are discussed in Chapter 5).

As a result of the extension of the project scope, a number of other related construction elements were added to the CA/T project . These were projects being constructed by other transportation agencies, including MBTA and Massport, within the boundaries of the CA/T project and being managed as part of the CA/T construction program. These "third party" costs are included in the overall budget of $10.4+ billion, categorized as "support" or "exclusions" from federally funded elements in budget descriptions.

Finally, in hindsight, it is possible to see what the impact of the inflationary pressures of more than a decade of design and construction of the Central Artery/Tunnel project has been on the cost of all he project elements. The provision for inflation for the period from 1985 to 2004 is estimated to account for close to $4.0 billion of the increase over the 1985 estimates. This is the equivalent of about 40% of the estimated cost of the entire program.

At the present time, the project is essentially fully designed and engineered, with the exception of planning the use of land area reclaimed in downtown Boston after the current Central Artery viaduct is dismantled and the tunneling system is completed. Construction is approaching 30% completion and, by the end of 1997, virtually all the major construction contracts will have been let. With the design and engineering controversies resolved for the most part, the project should be able to move ahead on schedule, barring any major occurrence of litigation or other unforeseen circumstance producing delay.

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[6] These completion dates were included in the Project Master Schedules Number 3 of 2/91 and Number 5 of 2/93 respectively.

Table 1.2-- SUMMARY OF CA/T COST HISTORY

DATE/CATEGORY	COST	COMMENT
1983-85 -ORIGINAL ESTIMATE Preliminary engineering --the basis for Federal approvals	**$ 2.564 B.**	This was the first estimate of total cost for the core components of the Artery and Tunnel based on early conceptual designs and engineering
BASIC SCOPE ADDITIONS FOR TRAFFIC FLOW IMPROVEMENT	**CHARLES RIVER CROSSING ---------- $ 508 M.**	Crossings redesigned to handle traffic so as to alleviate community concerns and improve riverfront conditions
	HOV LANES ---------- $ 262 M.	FHWA et. al. proposed to bring project up to modern highway standards
	I-93 South extension-- $ 130 M.	Rebuilding of SE expressway viaduct to Mass. Ave.
	Rte. 1A interchange --($18.0 M)	Revised plan
SPECIFIC COMMUNITY AND ENVIRONMENT IMPROVEMENTS	**S. Bos. Tunnel Covers-- -$ 176 M.**	To protect community from traffic noise
	S. Bos. ROW additions-- $ 173 M.	To provide better traffic flow and property access
	S. Bos. By-pass Road---- $ 23 M.	Haul road for trucks to mitigate effects of construction activity
OTHER PREPARATION AND ENVIRONMENTAL MITIGATION	**Hazardous waste disposal program - ---------- $ 141 M.**	Required by State and Federal law
	Utility relocation ---------$ 85 M.	Required to tunnel under built up sections of the city
NON- CONSTRUCTION OVERHEAD	**B/PB Contract add on --$ 263 M.**	Adjusted for additional scope
	Insurance ---------- $ 237 M.	To save cost in construction bids
	Other ---------- $ 642 M.	Detailed mitigation measures resulting from final design solutions
1993 REVISED ESTIMATE	**SCOPE CHANGES ---- $2.622 B.** **+ 1985 ESTIMATE -----$2.564 B.** **+ INFLATION ---------- $2.554 B.** **=TOTAL ---------- $ 7.740 B.**	
1993- 1995 CHANGES	**SUPPORT COSTS ----- $ 998 M.**	Other project costs not using Federal highway funds
	DESIGN CHANGES----$ 259 M.	
	INFLATION ---------- $1.387 B.	Inflation to end of project -2004
1996 REVISED ESTIMATE	**93-96 CHANGES -----$2.644 B.** **+1993 ESTIMATE-------$7.740 B.** **= TOTAL ---------- $10.384 B.**	These costs are the basis for the 1996 Financial plan

CHAPTER 2 -- THE CURRENT BUDGET

Understanding the current budget of the Central Artery/Tunnel Project is preliminary to an examination of the potential for cost reduction. In this chapter, therefore, we review first the structure and status of the budget. Second, we analyze the budget allocation by program area for mitigation, and, finally we review the scope changes and their implications.

Part 1. STRUCTURE AND STATUS

To determine what is included in the budget and its status, we have examined the management reports which the CA/T project staff produces every month to track all aspects of project costs, including changes in allocations to various categories due to shifts and changes in construction bids, change orders and reallocations of budget items. Table 2.1 shows the way the overall budget is reported and summarized. The first column is the current budget with costs of all project components "unescalated" -- that is, not reflecting the effects of inflation during the period from now to the year 2004. The second column shows the current budget with costs "escalated" by about 9% to reflect the anticipated inflation, and the third column provides a forecast of potential costs for all components based on current trends in project expenditures.

The budget includes a "credit" for the recovery of air rights sales from the land made available as a result of the depression of the Artery. These are estimates of what the MTA as project "owner" might be able to recover from the sale of these parcels at some future date, a situation that will depend on the status of the real estate market in downtown Boston at the time of potential sale. Since this is likely to be a decade in the future, this figure can be considered as a speculative guess at this time. Without this credit, the current total budget (escalated) would be $10.991 billion rather than the $10.736 billion as shown below.

Table 2.1 -- CA/T OVERALL COST

(as of 1/31/97 - per CA/T management report)

CURRENT BUDGET (UNESCALATED)	CURRENT BUDGET (ESCALATED)	POTENTIAL (FORECAST)
$ 9.758 B.	**$ 10.736 B.**	**$ 10.711 B.**
(91%)	**(100%)**	
(excludes air rights credit)	(includes air rights credit)	(includes air rights credit)

Note also that the current budget as of January 1997 is higher than the $10.4+ billion figure in the Finance Plan, reflecting seven months of changes in construction estimates, bid experience, and increases in other costs. As the project moves ahead into the period of maximum construction, the monthly movement of the budget bears careful monitoring, particularly to determine the causes of any upward or downward trend both in the overall budget and specific components. While the federal and state oversight agencies watch these numbers carefully, we recommend that the legislature also keep watch. This will be essential not only for tracking CA/T progress but also for anticipating legislative action on funding and other measures.

Table 2.2 shows the breakdown of the overall budget by funding category -- the direct costs (close to

85% of the total) are those which are eligible for and supported by federal highway funds, while the remaining 15% are categorized as "support costs". These include the budget for those elements funded primarily by state and local transportation agencies (third parties) but within the scope of the CA/T project. These agencies include the three transportation authorities – the Massachusetts Port Authority (MPA), the Massachusetts Bay Transportation Authority (MBTA), and the Massachusetts Turnpike Authority (MTA).

Table 2.2 --CA/T OVERALL COSTS BY FUNDING CATEGORY
(Current Budget Escalated)

Supported by Federal highway funds	**DIRECT COSTS**	**$ 9.046 B.**	(Includes credit of $255 m. for sales of air rights)
Primarily State and local agency funding	**SUPPORT COSTS**	**$ 1.690 B.**	(Includes third party costs of $ 270 m.)
	TOTAL COSTS	**$10.736 B.**	

Table 2.3 shows the overall budget broken down by function: 1) those associated with the design, engineering and management of the project including insurance; and 2) those associated with actual construction, including the more than 119 separate construction packages plus the costs of acquiring rights of way, the relocation of utilities (force accounts), and geotechnical services required to prepare the project area for the construction of the roadways and intersections. Note that over one quarter of the budget has been allocated to design/engineering/management related costs -- a reflection, we believe, of the complicated and time-consuming nature of the engineering required, including the construction related and long term mitigation solutions which building in this dense urban environment demanded. The preliminary design work was undertaken by the Bechtel/Parsons Brinkerhoff Joint Venture and is included in their budget. Final designs undertaken by other engineering firms are included in the section design budget. The insurance budget includes the cost of insuring the construction work against accidents -- a service which is being purchased centrally by the CA/T project rather than by individual construction contractors as a cost saving measure.

Table 2.3 --CA/T OVERALL COSTS BY FUNCTIONAL CATEGORY
(Current Budget Escalated -- Direct and Support Costs Combined)

DESIGN/ENGINEERING AND MANAGEMENT COSTS	CONSTRUCTION RELATED COSTS
$ 2.933 B.	**$7,803 B.**
(27%)	**(73%)**
B/PB JOINT VENTURE -- $ 1.632 B.	**$ 7.257 B. --- CONSTRUCTION PACKAGES**
SECTION DESIGNS -------$ 1.028 B. (includes force account designs)	**$. 801 B. --- RIGHT OF WAY UTILITY RELOCATION** (Force accounts) **GEOTECH**
INSURANCE (MGT. RES.) -$ 0.273 B.	**($. 255 B) ---- Air rights credit**

Table 2.4 shows the amount of the overall budget committed as of the end of January, 1997. Close

to $7.0 billion, over 65% of the entire cost of the project, has already been allocated to various project activities, including both design and management functions and construction contracts. Over 60% of the direct construction budget and over three-fourths of other project costs have been committed, reflecting the status of a project virtually all engineered and well underway in the construction program. (Note that according to the February, 1997 Management Report, the committed amount had reached $ 7.294 billion, and in the March Report, $ 7.697 billion).

Table 2.4 CA/T OVERALL COSTS COMMITTED
(as of 1/31/97)
Total = $ 6.936 B. (65%)

OTHER PROJECT COSTS	DIRECT CONSTRUCTION
$ 2.219 B. (76%)	$ 4.717 B. (60%)

Table 2.5 shows the amount of uncommitted current (escalated) budget along with the potential forecast as of the end of January, 1997. The expected "to go" costs represent just over one third of the overall budget.

Table 2.5 --CA/T UNCOMMITTED BUDGET
(TO GO COSTS - as of 1/31/97)
DIRECT AND SUPPORT COSTS COMBINED

	CURRENT BUDGET (ESCALATED)[1]	POTENTIAL FORECAST[1]
TOTAL	$ 10.736 B.	$ 10.711 B.
COMMITTED (1/31/97)	$ 6.936 B.	$ 6.936 B.
UNCOMMITTED	$ 3.800 B.	$ 3.775 B.

1. Includes credit for sales of air rights.

Table 2.6 shows the allocation of uncommitted costs by function: 1) for construction which accounts for over 87% of the remaining budget to be committed; and 2) other project costs, of which the cost of the Joint Venture is the major item. It is expected that much more of the remaining uncommitted portions of the construction budget will be allocated to construction contractors by the end of 1997.

Table 2.6 --CA/T UNCOMMITTED BUDGET ("TO GO" COSTS) -- BY CATEGORY

(as of 1/31/97)

DIRECT AND SUPPORT COSTS COMBINED

	BUDGET (ESCALATED)	FORECAST
CONSTRUCTION		
CONSTRUCTION PACKAGES	$ 3.184 B.	$ 3.384 B.
FORCE ACCOUNTS	$ 113 M.	$ 124 M.
RIGHT OF WAY	$ 44 M.	$ 102 M.
Air rights sales	($255 M.)	($ 255 M.)
Geotech	0	0
CONSTRUCTION TOTAL	$ 3.086 B.	$ 3.355 B.
OTHER COSTS		
B/PB MANAGEMENT	$ 638 M.	$ 638 M.
DESIGN CONTRACTS (Includes section and force accounts 3rd party)	$192 M.	$ 172 M.
INSURANCE	($ 241 M.)	($390 M.)
MANAGEMENT RESERVE	$ 125 M.	0
OTHER TOTAL	$ 714 M.	$ 420 M.

This picture of the budget and its allocation reflects a project which is substantially into the construction phase, providing little, if any, opportunity to undertake changes in the scope, planning, design, engineering, or other aspects of the project, including changes in the agreed upon mitigation measures which have been built into various construction contracts. To a great extent, the future of the project lies in the hands of the construction contractors who have been given a go-ahead to build the various project elements as designed. Their ability to perform within their contracted budgets and meet all the commitments agreed to will be the key to completing the project within this budget.

Part 2. BUDGET ALLOCATION BY PROGRAM AREA

The $10.4+ billion is allocated to 119 contracts covering engineering, design and construction management spread out over some 7.5 linear miles of area in downtown Boston and adjacent communities. In the Management Reports, the budget is allocated to three major segments: the I-90 packages (the segments connecting Mass Pike to the Airport through East Boston and the Ted Williams

Tunnel), the I-93 packages (the segments including the Central Artery and its connections to I-93 North and the Southeast Expressway), and the system-wide packages. For convenience in examining costs and the consequence of possible reductions, the project has been broken down into eight major components, five of which comprise the **core elements,** and three of which are **essential connections;** (See Figure 2, Cost Allocation Map.)

The Core Elements include:

1. The Artery-Central -- this is the area between Causeway Street and High Street in downtown Boston where the existing Artery (six lanes) is elevated on a structure which is both substandard from a traffic point of view and structurally obsolete. The existing elevated structure is a barrier restricting the flow of pedestrian and vehicular traffic between such important attractions of downtown Boston as the Faneuil Hall Market Place, and the New England Aquarium, the North End, Rowes Wharf, and other waterfront areas. These are the key attractions for many if not most of Boston's visiting tourists and residents seeking entertainment. Both the Market Place and the Aquarium are among the most important attractions in the region, each drawing in the neighborhood of 3.0 million visitors a year. The plan is to put this section of the Artery underground in a tunnel system that would have connections to the Sumner and Callahan Tunnels without disturbing the operation of the Blue Line of the MBTA and provide surface circulation and protection against noise, dust, and other nuisances to the abutting residents and commercial establishments during the lengthy construction process. The program calls first for the construction of "slurry walls' on either side of the existing Artery strong enough to support the existing structure. Then a "bridge" will be built at the surface to carry the existing roadways. Under this "bridge" a large trench up to 150 feet deep will be excavated, after all the utility lines have been relocated, into which the roadway tunnels will be placed. When this is done, the trench will be filled in and the existing artery structure will be removed. In its place will be an attractive pedestrian-friendly urban boulevard, park land and sites for new downtown-related development. The extensive tunneling for this section of the Artery, along with all the other tunnel sections, requires that a number of expensive ventilation buildings be constructed. The **actual cost of construction** of this component, for which the engineering designs are complete, is estimated at **$1.5 billion**, and the **total project cost** including utilities, right of way, engineering and share of management and insurance costs is **$2.1 billion**, or **20% of the total**.

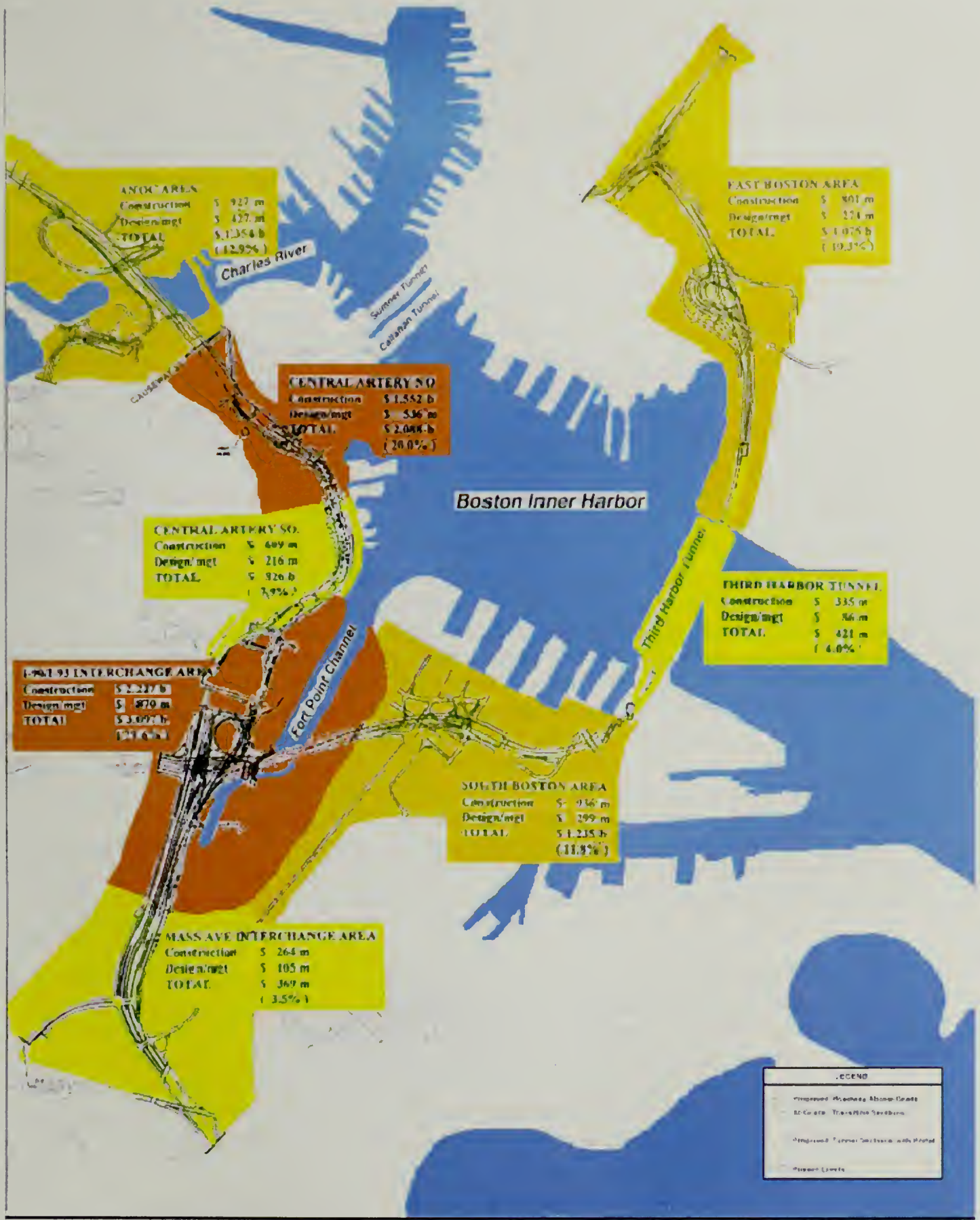
2. The Artery-South -- this is the area between High Street and Kneeland Street where the Massachusetts Turnpike (I-90) currently ends and where the existing Artery runs through the Dewey Square-South Station Tunnel before emerging on the elevated structure at High Street. The plan is to realign and expand the existing tunnel to carry southbound traffic and to build a new tunnel under Atlantic Avenue adjacent to South Station to carry northbound traffic. The construction of the new tunnel will be deep enough to permit the MBTA's Red Line to operate without interruption and will also provide the right-of-way for the new South Boston Transitway, a light rail system which will connect the South Station area with the fast developing commercial areas on the South Boston industrial waterfront. As with the central section, slurry walls will be constructed and existing roadways supported by a "bridge" to allow excavation of the trench into which the new north bound roadway will be placed under Atlantic Avenue. **The actual construction cost** for this segment, now underway, is

$ 516 million, and its share of utility relocation, right-of-way, engineering and management costs bring the total to **$826 million or 7.9%** of the project total.

3. The I-90/I-93 interchange at South Bay -- this is the key intersection on the CA/T system, for it is designed to provide the interchange that will allow North-South traffic moving on I-93 to interchange with the East-West traffic moving on I-90 (the Mass Pike) and connecting through the Ted Williams tunnel to Logan Airport. The interchange will make it possible for people and goods coming from the south and west of downtown Boston -- the location of well over half the population and businesses of the metropolitan region -- to by-pass the Central Artery and the Sumner and Callahan tunnels in travel to the airport and the North shore. **Without this interchange, the CA/T traffic scheme will not work.** The plan is very complicated, for it requires a series of tunnels, viaducts and entrance and exit ramps operating at five different levels. This requires tunneling under the Fort Point Channel, the South Station railroad facilities and MBTA's Red Line, traversing an area of very poor soil conditions, and a highly sensitive environment. It is one of the most difficult engineering design problems anywhere on the U.S. Interstate Highway system. The plan required very intricate alignment design to avoid creating problems for the Gillette Company, home to one of the region's most important industries, and to provide safe and sensitive access to the Chinatown community, one of the treasures of downtown Boston. As a result, this intersection will be the single most costly construction of the entire CA/T system, requiring a set of interconnecting tunnels, viaducts and ramps crossing existing railroad lines, subway tunnels and a waterway. **Actual construction**, now underway, is estimated to **cost $2.0 billion,** with about 42% of all costs to design and relocate utilities and 32% of all engineering design costs going into this piece of the project. With its share of management and other costs allocated, the total for the South Bay interchange will be **$3.1 billion, or close to one third (29.6%) of the total CA/T project cost.**

4. The South Boston tunneling and interchange -- this piece of the project connects the South Bay interchange with the Ted Williams Tunnel under Boston Harbor, through a series of cut and cover tunnels. It also includes the haul road through South Boston, which has been built and is in operation to by-pass truck traffic around the South Boston residential community. When completed, the planned interchange, with new surface streets in what has been a relatively inaccessible part of the industrial and commercial area of the South Boston peninsula sandwiched between downtown Boston and Logan airport, will be brought into a development mode offering important possibilities for new economic development related to these key activity centers. This development process has already begun. **Actual construction cost** for these parts of the system is **$ 887 million.** However, the right- of- way acquisition and the complicated designs required to connect with local streets and the South Boston Transitway made the allocation of these costs to the project somewhat higher than for other segments of the program. Total costs are estimated at **$1.23 billion or 11.8% of total project cost.**

5. The Ted Williams Tunnel -- this tunnel has already been constructed and is in limited operation, pending completion of the South Boston and South Bay interchange portions of the system. It also



CAT COSTS ALLOCATED BY AREA --Figure 2

Central Artery/Tunnel Project Map

MASSACHUSETTS HIGHWAY DEPARTMENT
CENTRAL ARTERY (I-93) Tunnel (I-90) Project

represents the lowest cost of any of the eight project components. The **tunnel itself cost $327 million** to put into place, and with the other allocations, the **total cost** of this section of the system is **$421 million, only 4.0% of total project cost.** This is the only portion of the project that did not disrupt an existing neighborhood. Only the harbor floor, home to important fish species, had to be protected.

The three essential connections include:

1. The ANOC connections (the Area North Of Causeway Street) -- this piece of the project provides the connections of the underground portion of the Central Artery and Sumner-Callahan tunnels with the existing Interstate I-93 north of the Charles River via a new bridge, with Storrow Drive at Leverett Circle via new tunnels snaking around and under the North Station and the Fleet Center area, and with Route 1 and the Tobin Bridge via ramps to the City Square tunnel in Charlestown. This part of the project, which is still in the final design stage, has proven to be the most controversial. Before the current plan was decided upon and approved by all concerned, there was a significant delay in the whole project schedule as the design process went ahead. **Despite the extensive and expensive efforts to handle the environmental and esthetic concerns of the impacted communities, there are still law suits pending on this section of the project.** According to many observers, **the delay in obtaining consensus** on this segment added important costs to the program through inflation and additional project elements. The centerpiece of the ANOC program will be an elegant single stay suspension bridge designed to carry I-93 traffic across the Charles River. However, this is not the most costly piece of the program. This honor is reserved to a complicated series of tunnels, ramps and viaducts needed to provide the Storrow Drive- Route 1 and the Sumner-Callahan tunnels connections. Actual construction of this system is estimated to cost **$801 million, with a total cost of $1.354 billion** including the sizeable costs of design and associated utility relocation. **This represents 12.9% of total project cost, the third largest of the eight components of the CA/T project.**

2. The Mass. Avenue connections -- this piece of the project provides a new viaduct to connect the South Bay entrance of the Central Artery with the Southeast Expressway where it intersects with Mass. Avenue at the big bend. It is probably the least complicated section of the entire CA/T project, for it requires no tunneling and uses existing rights of way through an area with less economic and commercial activity than other areas. The total cost for the section, now well underway, is **$369 million or only 3.5% of the total, of which $255 million is actual construction.**

3. The East Boston connections -- this project involves connecting the Ted Williams Tunnel, which emerges in the Logan Airport terminal area, with Route 1A in East Boston, the major highway serving the adjacent North Shore communities. It is a complicated interchange involving not only connections with the airport's terminal access roadways, but also present and future transit improvements to the MBTA's Blue Line, including a new airport station. The engineering for these connections has not reached the final design stage. **Currently these components are estimated to cost $1.074 billion, or 10.3% of the total, of which $774 million is in actual construction**.

Part 3. THE BUDGET FOR MITIGATION

Scattered throughout the budgets allocated to the projects in these eight areas are substantial sums for mitigation. The word "mitigation" is defined as **"the lessening in force or intensity of harshness or pain"** resulting from a particular action. The term is most appropriate in the case of the "urban surgery" now being performed in the center of the Boston region as the Central Artery/Tunnel project moves ahead. Mitigation is and has been a critical element not only in the planning and design scheme but also in its overall execution.

The cost of mitigation can be viewed as the funds used to plan and build the highway system which would not have been required if the highway were not built in such a difficult location. Indeed, one can view the difference between the $2.564 billion initial estimate of 1985 and the $10.4+ billion in the Finance Plan as attributable mainly to mitigation. Note that virtually all the elements of additional cost are either related to scope changes designed to protect and enhance the urban and natural environment or to the time taken to work out the details of the over 2,000 environmental mitigation commitments resulting from the detailed planning, design and engineering process. (See Table 2 in Chapter 1.) During latter stages of the planning and design process, the original 2,000 environmental mitigation measures proposed were negotiated down to about 1,500.

For practical budgetary purposes, project management estimates that the cost for mitigation measures has ranged from $2 billion to more than $3 billion, or nearly one third of the total project cost. (See Table 2.7.) Within the context of the project's implementation, these measures fall into two broad types: operational and end-result mitigation. Operational mitigation measures include those taken during the project construction phase, such as traffic staging, general construction mitigation (noise and dust), keeping the elevated artery in operation during construction, and some ecology-related environmental mitigation such as the fish warning system used during underwater tunnel work. End-result mitigation includes measures with a more permanent effect, including environmental protection, community job training, archaeological/historical preservation, and measures taken to improve some aspect of transportation, pedestrian activity, and neighborhood aesthetics. They also include projects such as Spectacle Island, the South Boston Haul Road, and the reclamation of the Charles River banks for park purposes. A number of these projects were required for the project to pass essential environmental reviews as well as to secure needed funding and political support. They also underscore largely unquantified future benefits that an area can gain from project mitigation measures. Some mitigation measures fall into both the operational and end-result categories.

Altogether, MHD has formed a classification of these mitigation components. (See Table 2.8)

Table 2.7- Mitigation Cost Breakdown – $Cost in Millions

	Operational (Temporary Accommodations)
City of Cambridge	$81.7
ROWARS (right of way acquisition & remediation)	$80
Northern Avenue ramp	$8
South Boston Haul Road	$68
Police Details	$66
Impacts south of causeway	$60
Right of way	$57.8
Transport of clay to municipal landfills	$52
Premium for Excavated Material	$50
Rodent Control	$5
Replacement parking for tour buses	$5
Spectacle Island Dirt Disposal System	$45
Fire Test program	$44
Temporary traffic relief – South Bay	$44
Cost to keep Artery open	$400
Temporary barricades, walkways and lights for vehicular and pedestrian traffic	$40
Improvements to affected streets and walkways	$37
Atlantic Avenue Bypass	$36
MBTA Parking Garage	$35
Improvements in East and South Boston to avoid interference with airport and minimize noise	$260
Red Line underpinning	$25
Temporary Tobin Bridge loop ramp (CANA)	$20
City of Boston (for traffic planning)	$20
Street Sweeping	$20
Noise Control	$20
Surface Artery traffic management	$2
City of Boston Consultant on traffic activity	$2
Boston Fire Dept requirements	$2
I-93 Northbound bypass	$17
Noise Buffer Park	$15
Interim ramp – Albany Street	$15
Dust Control	$10
Snowplowing	$10
Community Group training	$1.8
Redesign to accommodate Harbor Towers	$1.5
Small Business Program	$1.3
Fish startle system	$1
Dirt removal safety	$1
Boston Police Dept requirements	$0.8
NE Aquarium walkway	$0.4
Total (52% of mitigation cost)	$1648.8
	End Result (Improvements)
Redesigned Charles River Crossing –increment over Scheme Z	$351
Charles River Basin Master Agreement	$80
Historical Conservation	$13
HOV Lanes	$649
Fort Point Channel improvements	$5
North End Ferry terminal	$3
East Boston Ferry terminal	$0.5
Wetlands replenishment	$2.5
Long Island restoration	$0.5
Tunnel Covers – East Boston	$58
Tunnel Covers/Roofs – South Boston	$202.6
Spectacle Island Beach Nourishment	$8
Mass Ave Interchange	$194
Total (48% of mitigation cost)	$1337.6

Sources: CA/T project memoranda, contract listings, Boston Business Journal, 5/16-22, 1997

Table 2.8 -- CA/T Project Classification of Mitigation components

Air Quality	Joint Development	Roadway Design Elements
Arts	Material Disposal	Surface Restoration
Building Design Elements	Noise	Transportation: bicycle parking, transit and traffic
Construction Mitigation	Parks and Open Spaces	Utilities
Economic Compensation	Pedestrian	Vibration
Emergency Response	Pest Control	Water
Highway Maintenance and Operations	Public Outreach, Process and Signage	
Historic Preservation	Right of Way	

Overall, mitigation practices that have emerged from the project have been dictated by the difficult urban environment in which the project is being built and the commitments that project sponsors had to accept as the price of building in this environment. It required intense project-neighborhood interaction. An extensive community-liaison network is in place to focus on advance notification of construction activities and related inconveniences. Through this mechanism groups in the affected communities have significant influence in day-to-day construction operations. The public dimension of the project involves an array of community based groups ranging from super coalitions like Mass Move 2000 to smaller groups representing distinct constituencies like the Fort Point artists and funds for community training.[7]

Through the umbrella groups, scores of private and nonprofit organizations have come to play an important role in project oversight to complement the role played by the legally mandated state and federal agencies. Specifically, they independently track the 1500 mitigation measures which were the quid-pro-quo for project acceptance. Changes in these commitments in the name of cost savings can be expected to raise vehement and substantive protests from these groups.

Cost pressures on the mitigation budgets

While the costs of the end-state mitigation measures are included in the construction program and have either been built or have funds for them fully fixed and committed, the costs of the operational mitigation measures are more variable. For the most part, these costs are accounted for in the specifications for each of the bid packages let out to the construction contracting teams. Now that the construction process is in full swing, especially in the downtown area, there is more hands-on experience with the actual field conditions.

The consensus among contractors whom we interviewed is that construction mitigation efforts, especially those related to abutter concerns, are far more complex and more time consuming than they expected. Some contractors even expressed the opinion that CA/T and MHD managers should have done more about dealing with abutter issues earlier in the project planning and design phase. Arguably the most difficult mitigation-related issue from CA/T and MHD's perspective has involved the

[7] $1.525 million was earmarked for community based training in Boston and $.208 million was earmarked for community based training in Cambridge. The intent of this item is to "provide minorities, women and residents of the communities impacted by the project with access to job training opportunities associated with the project." There have been benefits, both political and substantive, from this program. (Source: CA/T Project Construction Awards List dated December 2, 1996 and MHD Central Artery Training Program: undated flyer; see also April 1997 op-ed piece by Joan Wallace Benjamin, President, Massachusetts Urban League.)

inherent conflict of interest that exists between business and residential interests. Conflicting needs mean that the scheduling of work is a delicate balancing act. Businesses prefer to minimize construction impacts during the daytime in order to keep traffic moving; residents are more concerned about minimizing impacts at night to reduce noise.

The origins of this dilemma lie in the unique residential-business mix – where commercial establishments and households share the same or adjacent structures and neighborhoods a situation that is typical of significant portions of downtown Boston. Of the eight major project areas, the business-resident conflict is especially acute in the following neighborhoods:

ANOC: *Charles River Park, Long fellow Place, Beacon Hill, Charlestown, East Cambridge, North End*

Artery North: *Harbor Towers, Rowes Wharf, Leather District/South Street/Atlantic Avenue*

Artery South: *Chinatown, South End, Worcester Square, Ellis Neighborhood Group*

Fort Point Channel: *Loft District, Summer Street*

East Boston: *Jeffries Point, "8A" Area.*

MHD also acknowledges that construction has been noisier and dustier than anticipated. The single biggest construction impact of concern to residents thus far has been noise and noise related activities. Air quality complaints will increase as dust becomes a more difficult problem during the summer months, when construction activity picks up and more people are outdoors. Both noise and dust complaints are likely to increase in the near term, as the pace and quantity of construction accelerates and diminish in another 1 ½ to 2 years once the project goes underground.

The current construction sequence encourages contractors to do the noisiest work during daytime hours. If contractors go outside contractual work hour restrictions in order to accommodate neighborhood complaints, change claims are generated. Information from both MHD and contractors indicates that, in order to preserve understanding and goodwill, contractors have generally responded to direct requests of the communities without putting in immediate change orders. However, the project's heavy construction phase has not yet begun in earnest in the residential areas that are likely to experience significant construction impact.[8]

In anticipation of an increase in noise-related complaints, project managers, contractors, and community groups have been experimenting with innovative methods for noise minimization. The project has also increased its own monitoring and enforcement efforts. Future contract specifications include tighter restrictions, and there is some community pressure to apply the new restrictions

[8]Also, project noise limit specifications are set at no more than 5 decibels over the background noise level for the city. Because Boston is so densely inhabited, the background noise level is fairly high; therefore, contractors can be operating within project noise specifications and still be too noisy from the community's perspective. The project is so large, pervasive and well-known that it has experienced a "lightening rod" effect in that unrelated problems in a neighborhood located within its boundaries are attributed to the project. For example, some North End residents recently complained about dust being generated by the project even though construction had not yet begun in the their particular locale.

retroactively. Contractors are willing to comply with tighter standards but would expect to be compensated. Clearly, construction operational mitigation issues contain seeds for upward pressure on project costs. The project has negotiated some night work within certain parameters.

According to CA/T- MHD, the end cost to the project of delaying the schedule by not doing any work at night would be an additional $20-$30 million per month.

Project staff have described the mitigation process as "evolutionary." If this process entails a continued proactive approach – but one that does not impose additional costs – total mitigation costs may not increase. Unexpected issues, disputes or aggressive community advocacy as construction begins in particular neighborhoods or areas could create an upward cost trend.[9]

Part 4. SCOPE CHANGES AND IMPLICATIONS

As an essential part of our analysis, we examined the possibilities for cost reduction through changes in the scope of the project and its various elements, ranging from halting or putting a moratorium on current construction activities to possible reductions in the size of various components.

A moratorium on construction

If construction were halted now, when close to two-thirds of the funds have been committed, the region would lose the benefits of the segments already completed and for the next decades traffic circulation would continue to deteriorate with serious consequences for downtown Boston and the region as a whole. With construction started on all major components, there is no convenient way to make the traffic system work with the elements in place already. There would be additional cost associated with contract close-out and related litigation. As a result:

- The value of the completed investment in the Ted Williams Tunnel would be marginalized because there would be no convenient connection between it and I-90. Access to the airport would be essentially the same as it is today.
- The Central Artery would remain as it is today, but continuing to deteriorate structurally, becoming less and less safe, and continuing the pollutive and blighting effects on the adjacent neighborhoods as it does today.

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9 A recent Boston Business Journal article (May 16-22, 1997) recounts the concerns of small business owners impacted by construction, and claims that the $1.3 million set aside for the project's Small Business Program (used for assisting small businesses with promotional materials) in no way compensates for loss in sales and other revenue. Pressures from this business group may abate once construction moves underground; however, continued revenue losses and possible building damage caused by underground digging could drive costs upward.

- Any program to make the improvements later in the next century would cost substantially more than the $3.8 billion remaining to be committed, given inflation and the re-engineering that would be required. This option would be close to catastrophic.

Reducing the scope of the remaining elements

We have studied the project management proposals to reduce the scope of remaining elements of the project, principally by cutting out some ramps and interchange connections and reducing some travel lane capacity. Nine of these were presented in the Finance Plan of September, 1996, with a combined reduction of close to $1.4 billion, or about 29% of the remaining construction costs. . The Finance Plan proposals are discussed below by size of potential reduction.

South Bay Interchange -- eliminating the I-90/ I-93 connections -- ($500 million) -- would involve eliminating from the construction program currently underway the complicated set of ramps connecting the two interstate routes. This would result in a situation in which North-South traffic on I-93 would not have access to the MassPike or the Ted Williams Tunnel, nor would the I-90 traffic have access to the Southeast expressway and the Central Artery as it has today. Each Interstate route would thus serve only through movement, without the convenient possibility to interconnect, except through local streets. This solution would severely limit the value of the whole CA/T program by restricting the convenient interchange of multi-directional traffic at the key point in the whole metropolitan highway system. Project management lists the probability of this solution as very low, probably unacceptable to the Federal Highway Administration, environmental agencies, and the affected local communities. The re-engineering required would provide major delays in the construction schedule.

East Boston infrastructure improvements -- curtailing the current program -- ($350 million) -- would involve rearranging the timetable and design of the connectors joining the Ted Williams Tunnel to Route 1A to allow better solutions for the traffic circulation in the whole area north of Logan Airport. Relocation of the Airport station of the Blue Line is an essential part of the program. At present, these improvements are included as part of the CA/T project, but some observers feel that the project should be designed and constructed as part of Massport's program of airport and related improvements, with a revised and stretched out timetable. Others feel that these improvements should continue as part of CA/T, to insure that both traffic solutions are in place as soon as possible and environmental commitments are met. This piece of the project has not yet gone to final design. As a result, there may still be some room to rearrange some of the project elements and save some cost to the CA/T project by assigning the construction management to Massport engineering staff and consultants. However, changing the existing arrangements would only contribute to cost savings if MPA, MBTA, MHD and the local community could agree on the best way to handle the situation.

ANOC - Leverett Circle -- deleting planned intersection improvements -- ($200 million) -- would involve keeping the existing configuration of the Leverett Circle intersection, a major congestion

point at present. The whole area around North Station and the Fleet Center is undergoing major change at the moment. Plans for handling connections to the Central Artery are an essential piece of an improvement program which includes building a new tunnel for the Green Line to connect to Lechmere and a new Orange Line-Green Line transfer station adjacent to the Artery. Some observers feel these improvements could be deferred and made part of a larger program involving improvements to MBTA's Green Line, while others feel that without these improvements as part of the CA/T project, this area will continue to be a major traffic bottleneck. Changing the plans at this stage would be disruptive and require delays to secure new environmental and other approvals.

ANOC - Storrow Drive/ Artery connection -- deleting planned connecting tunnels -- ($100 million) -- would involve eliminating the tunnels designed to connect Storrow Drive to the Central Artery and Sumner-Callahan tunnels. While this connection is made today by the viaduct connecting the Artery with Leverett Circle in the North Station area, it would be eliminated in the future if the tunnels were not built. To get to the Artery and the Sumner-Callahan tunnels, Storrow Drive traffic would have to use local streets. This would create serious traffic problems for the Beacon Hill and West End communities and would open up controversies which have been long settled in the planning process. Redesign would hold up the project schedule.

I-90 and I-93 HOV lanes -- deleting planned extra lanes for high occupancy vehicles -- ($100 million) -- this would involve removing the HOV lanes which were added to the project to provide more flexibility in the traffic flows to meet the standards for modern urban highways. Some observers feel the HOV lanes are not workable and not really essential, others feel that to spend so much money to improve these interstate segments without HOV lanes would be "penny-wise and pound foolish." Again, a "notice of project change" would be required. FHWA and other supporters of the HOV system could be counted on to raise serious doubts about the wisdom of the move.

South Boston Interchange -- deleting planned access point to seafront area -- ($ 50 million) -- would involve deleting the intersection which provides the main new access to the South Boston seafront area. It would thus hamper new road access to this area and decrease the potential of the area to handle new economic development. As a result, one of the key land development benefits of the whole CA/T scheme would be lost, along with the opportunity of this area to contribute more to the tax base of Boston.

Central Artery - Dewey Square Tunnel -- deleting planned improvements -- ($ 50 million) -- would involve eliminating the project to realign the existing walls in the Dewey Square tunnel to make for easier and safer traffic movements. This could be done without major schedule impacts, but would lower the standards for the Central Artery from a traffic flow point of view. Because of tighter turning and weaving patterns, some element of danger would be added to the new Artery when completed.

Central Artery - Ramp R-T -- eliminating access to surface streets -- ($ 25 million) -- would eliminate a ramp now planned for the Atlantic Avenue area; the main effect would be to dump more traffic onto the local street system in and around South Station and the financial district. That would not be in the best interests of improving the environment in this important downtown activity center.

ANOC - Charles River Bridge -- change bridge design -- ($ 10 million) -- would cut back on the aesthetic quality of the single stay suspension bridge crossing the Charles, which would require opening the environmental review process in the CA/T's most controversial area.

Most of these changes would diminish the ability of the system to function to its most efficient level, cause more traffic to circulate in local neighborhoods, and bring into question the approvals for mitigation and environmental protection agreed upon to meet federal and state regulations and requirements of local communities. As a result, we do not feel that these types of scope reductions should be considered, except under the most adverse circumstances. They would be counter- productive, raise the possibilities of more delay and controversy, and not be in the best interests of the Commonwealth and the mission of the federal highway program.

CHAPTER 3 -- COST CONTAINMENT/ REDUCTION POTENTIALS IN THE CONSTRUCTION PROCESS

With more than 70% of the budget committed, more than 50% obligated, and more than 40% already disbursed[10], there is little opportunity to significantly reduce the overall budget for the project at this advanced stage.

As pointed out in Chapter 2, reducing the scope of the project would not, in our view, be wise public policy for it would negate too many of its long term benefits for the traveling public and affected communities, and create serious legal, administrative and other problems for which the Commonwealth would have to suffer the consequences. The budget includes extensive commitments to a wide variety of community and environmental interests, many of whose concerns are protected by law. While it is likely that the federal funding available in the future will not be of the proportion expected when the project was conceived in the 1970's and 1980's, there should be enough from federal sources to help the Commonwealth complete the project within overall budget parameters. However, as we will discuss in Chapter 5, state and local resources may be required to pay a larger portion of the costs. **Unless there is an unanticipated funding disaster and the project cannot proceed, we assume that the best course is to complete the project as soon as possible, relying on tight budget controls and efficient and effective management of the construction process to insure completion at the lowest possible cost.**

We have examined the question of how much cost saving potential there is in the CA/T project at this stage, considering that almost all the final engineering designs are complete, construction is more than 25% complete and most of the remaining 75% is to be put under contract by the end of the year. We have done this over the last few months through discussions with project management, construction contractors, oversight agencies, community groups and others. In this chapter, we will review our findings and conclusions in this regard, first by examining the budget scenarios that appear likely, and second, by describing cost containment and reduction measures applicable to the construction process in its current state, as identified through our contacts.

Part 1. -CA/T BUDGET SCENARIOS

Our analysis of the potential to reduce and contain costs is described by the various scenarios under which the CA/T budget would either expand or decrease.(See Table 3.1) **To reduce the overall budget by a major amount, by 10% or more than $1.0+ billion, (Scenario A), some drastic actions would be required which would have severe negative consequences.** These actions would include reducing the scope of the remaining elements through extensive elimination of planned capacities and interchange movements. This would result in reducing the traffic performance of the

[10] As of the CA/T Monthly Management Report of March, 1997 -- page 17a "Committed" refers to the dollar value of work that has been agreed to through contract. "Obligated" refers to dollar value of that portion of the work performed under contract; since the work has been performed as agreed to, the contracting agent has an obligation to pay for the work.

entire system. Local neighborhood streets would be left to absorb the burden. This would also entail possible reduction or elimination of mitigation measures already included in the construction packages, a situation which could bring on consequent costs and damage claims from community and environment groups, and contractors. It would also require renegotiation of agreements with federal agencies and local interests, along with extensive redesign and engineering.

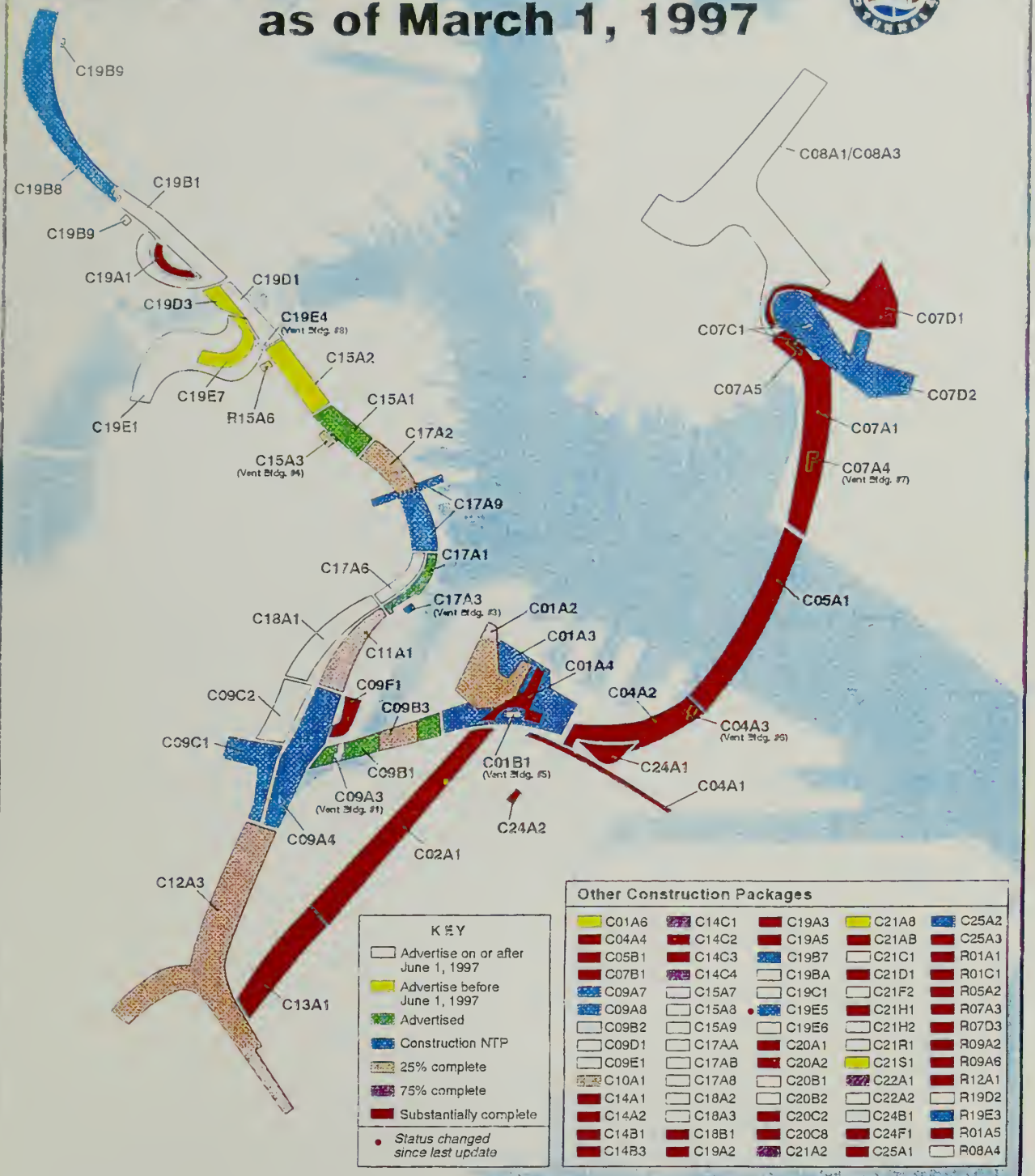
Another possible device to significantly decrease the CA/T budget would be to transfer major scope elements out of the CA/T program to the budgets of other agencies, such as the Massachusetts Port Authority (MPA), Massachusetts Turnpike Authority (MTA), or the Massachusetts Bay Transportation Authority (MBTA), and to defer construction until each agency could absorb the costs. However, this is no real cost saving. It is cost deferral at best, with possible consequent higher costs at a later date.

At the other extreme, an increase of the budget of 10%+ or more than $1.0+ billion (Scenario E), could come about with major traumatic incidents in the current construction environment. This could include extensive delays in the construction schedule caused by any combination of the following: unfavorable lawsuits, (at least one suit - mainly involving the Central Artery North Area (CANA) construction program on the Cambridge side of the Charles River – is still pending); major new scope or mitigation measures not currently planned (possibly resulting from unforeseen problems with local communities); extensive contractor claims resulting from unresolved disputes; and/or construction disasters involving very high insurance claims that would ultimately force the CA/T program to absorb higher insurance premiums. In addition, a local economic downturn might also possibly force costs above the current plan. None of these possible traumas has yet affected the project. However, the construction process still has six years more to run.

Keeping the project within current budget parameters (Scenario C) will be no easy task. It will require continued application of strong cost containment measures and adherence to the construction schedule, particularly for those construction packages on the critical path. Because of the complicated sequencing of these packages, it is essential that contractors keep to the planned schedules, for delays in one package could hold up the work of the next and result in greater overall cost. Staying within budget parameters will also require that the project maintain its current pattern of construction bids coming in below office estimates. So far, this pattern (see table 3.2) has been relatively stable, but some of the largest and most difficult contracts remain to be bid. Also, to accompany this positive trend, the pattern of change orders submitted and acted on favorably must be kept within the current budget parameters, and contractor claims kept to the current low rate.

Increases in the current budget in the range of 2% to 4%, or from $ $250 to $450 million, (Scenario D) could occur with schedule delays and minor problems in the construction process. In a project of CA/T's magnitude, this level of change is not unusual. Indeed in the process of reviewing the Monthly Management reports since the beginning of the year, we have noted some upward movement in the construction budget that reflects some of these pressures. Schedule slippage in any major construction package, particularly those on the critical path, will increase costs, as will construction problems in tunneling, particularly since some unforeseen soil and utility conditions are not covered in the construction contracts and change orders would be required. Mitigation measures

Construction Status as of March 1, 1997



KEY

- Advertise on or after June 1, 1997
- Advertise before June 1, 1997
- Advertised
- Construction NTP
- 25% complete
- 75% complete
- Substantially complete
- • Status changed since last update

Other Construction Packages

C01A6	C14C1	C19A3	C21A8	C25A2
C04A4	C14C2	C19A5	C21AB	C25A3
C05B1	C14C3	C19B7	C21C1	R01A1
C07B1	C14C4	C19BA	C21D1	R01C1
C09A7	C15A7	C19C1	C21F2	R05A2
C09A8	C15A8	C19E5	C21H1	R07A3
C09B2	C15A9	C19E6	C21H2	R07D3
C09D1	C17AA	C20A1	C21R1	R09A2
C09E1	C17AB	C20A2	C21S1	R09A6
C10A1	C17A8	C20B1	C22A1	R12A1
C14A1	C18A2	C20B2	C22A2	R19D2
C14A2	C18A3	C20C2	C24B1	R19E3
C14B1	C18B1	C20C8	C24F1	R01A5
C14B3	C19A2	C21A2	C25A1	R08A4

Central Artery/Tunnel Construction Contracts

March 1997

Massachusetts Highway Department
Central Artery (I-93)/Tunnel (I-90) Project

0 800 1600 2400 3200 Feet

3.1.97

required but unanticipated in the office estimates for critical program packages in downtown Boston could also exert upward pressure on the costs, In addition, a pattern of future construction bids consistently higher than the pattern experienced to date would also have the same effect. Higher labor costs resulting from shortages in key skills could be one possible cause, along with "contractor overload," resulting in fewer contractors showing up to bid on future contracts.

To achieve an equivalent level of budget reductions in the scale of 2% to 4%, or $250 to $450 million, (Scenario B), the project would have to rely principally on measures to avoid all delays and unanticipated changes in planned scope for all remaining construction packages plus good luck in completing packages on critical path ahead of schedule. This will require the active application of as many as possible of the cost saving techniques available to project management and contractors involved in the construction process. Application of these techniques requires extensive cooperation among all the "parties at interest", not only the project management and the contractors, but the Legislature, other state regulatory agencies, and local communities as well.

Table 3.1 --CA/T BUDGET SCENARIOS

SCENARIO	LEVEL OF CHANGE	PERFORMANCE REQUIREMENTS
A. LEVEL 1 SAVINGS	**-OVER 10% -$1.1+ B.**	**WOULD REQUIRE MAJOR SCOPE CHANGES--** --extensive elimination of planned capacities and interchange movements resulting in reduced system performance -- extensive elimination of mitigation measures already included in construction packages (with possible consequent costs and damage claims) -- repermitting and renegotiation of agreements with Federal Agencies and local interests -- transfer major scope out of CA/T program to other agencies (not real savings)
B. LEVEL 2 SAVINGS	**-2% TO 4% -$250/$450 M.**	**WOULD REQUIRE SCHEDULE ADVANCES --** -- avoid all delays and unanticipated changes in planned scope - plus luck in completing construction packages on critical path ahead of schedule -- active application of all cost saving techniques in the construction process, including faster processing of change orders and VECP's, bulk purchasing, etc. -- early phase out of project management consultant
C.CURRENT BUDGET (escalated)	**$10.4+ B. ($11.0 B.)**	**WILL REQUIRE STRONG COST AND SCHEDULE CONTAINMENT --** -- no change orders other than those anticipated to date or absolutely necessary -- current schedule of critical path items kept without interruption -- no extraordinary patterns of bids exceeding office estimates (so far, so good) -- claims rate kept to current minimum -- consideration of change orders and VECP's only with construction period, rather than long term, impacts
D. LEVEL 1 INCREASES	**+ 2% TO 4% +$250/$450 M.**	**COULD OCCUR WITH SCHEDULE DELAYS AND MINOR CONSTRUCTION PROBLEMS --** -- schedule slippage in any major construction package, particularly those on the critical path -- unforeseen construction problems in tunneling, particularly with soil, water or utility conditions -- unforeseen mitigation measures required (C15A1 example) -- future construction bids pattern higher than estimates
E. LEVEL 2 INCREASES	**OVER 10% +1.0+ B.**	**COULD OCCUR WITH MAJOR TRAUMA** -- extensive delay s caused by unfavorable lawsuits (Cambridge) -- major new scope or mitigation measures not currently planned -- major contractor claims -- planned cost savings unrealized

Part 2. -MEASURES TO CONTAIN OR REDUCE COSTS IN THE CONSTRUCTION PROCESS

The setting for cost containment and reduction

At this advanced stage in the construction process, the dynamics of interactions among the "owner," the Commonwealth of Massachusetts, the Joint Venture program manager and design/engineering team, and the construction contractors, along with the affected "communities" will determine the ability to control, contain, and possibly reduce project costs. The laws of the Commonwealth governing the construction process for receiving and accepting contract bids; for abiding by labor, environment, and other regulations; and for resolving disputes among the affected parties, provide the backdrop for these dynamics. In our discussions with project management staff, construction contractors, oversight agencies, community groups and others, a series of measures have been identified that could be introduced or improved upon to help contain and reduce costs in the construction process. Some of the measures would require action by the state legislature, some upon the cooperation of other state agencies to improve administrative reviews, but many could be accomplished through changes in present project management practices. These measures fall into the following categories:

A. The bidding process for construction contracts

1. expansion of the bidders pool
2. bid acceptance policy
3. the A-B bidding process
4. exemption from filed sub-bid requirements

B. Construction contract management

1. partnering policy
2. change order policy
3. the VECP policy

C. Environmental assistance

1. review process relief
2. soil handling definitions
3. additional landfill sites

D. Other measures

1. police details
2. insurance program
3. approval of plans for vertical construction

This list is not exhaustive; and there may be other cost saving measures identified in the course of the construction process. However, they are the measures most frequently noted by those actively engaged in the CA/T construction program at the present time.

A. The bidding process for construction contracts

The CA/T program is currently in the most active period of letting construction contracts. While many contracts have already been let, there are enough remaining to warrant attention to those factors in the bidding process which can help reduce costs. There are a number of these as described below:

1. Expansion of the bidders pool

One of the keys to keeping construction costs under control is to insure that the project continues to receive the lowest possible bids from construction contractors. So far, the experience with receiving bids below the office estimates has been good (see table 3.2). However, there is some concern that this trend will not continue unless the number of new construction contractors expands; project management has conducted an active program to interest prospective contractors. To date, most of the lowest bids have been submitted and won by a small group of about 14 prime contractors. One of these has been involved as a lead or sub contractor on close to half of the contracts issued. On the one hand, the successful contractors feel that the size of the bidding pool is adequate. They note that the successful firms are able to handle the complicated demands of the project, "know the territory," and are able to secure the performance bonds needed to bid. Furthermore, the community groups most affected by the construction program feel that the experienced contractors have learned to deal with their concerns, a situation that may not exist with new construction contractors.

Table 3.2 - Difference between Low Bids and Office Estimates
(by Year of Award, $K)

Year	No. of Contracts	Total Amount Below Office Estimate	Average Amount Per Contract
1990	2	(578)	(289)
1991	8	(34,353)	(4,294)
1992	8	(83,636)	(10,455)
1993	12	(72,863)	(6,072)
1994	13	(67,264)	(5,174)
1995	13	(104,122)	(8,009)
1996	13	(64,300)	(4,946)
1997 thru January	2	40,061	20,030
Total	71	(387,055)	(5,451)

CA/T management provided a listing of all bidders at bid openings through April 1, 1997.[11] Table 3.3 shows the bid openings divided into groupings based on the office estimates. Bidding history shows that the larger the dollar value of contracts, the smaller the group of bidders. Except for Groups D and E, the number of bidders seems adequate; in these last two groups competition might be enhanced if future contracts can be divided into smaller pieces. Nearly all the bidders in Group E were joint ventures.[12]

Table 3.3 - CA/T Project Bid Openings

Group	Dollar Range	# of Bid Openings	# of Bids per Opening
A	$0 - $10 M.	43	5.23
B	$10 - $50 M.	15	7.50
C	$50 - $100 M.	7	4.71
D	$100 - $200 M.	7	4.14
E	$200 - $450 M.	10	3.50

The project management has initiated a nationwide program to recruit additional prospective construction contractors in an effort to encourage more bids on the large packages. We have heard unconfirmed reports, however, that many of the nation's larger highway construction contractors are not eager to participate in the CA/T program, fearing the difficult challenges of the project will make it hard to achieve expected margins on the work.

In addition, a potential problem of concern to the contractors and management alike which could drive up the cost of future bids is a shortage of skilled labor. The amount of CA/T construction now under contract is so massive that most of the skilled labor pool available locally is already employed. The ability of existing contractors to keep their work force scheduled on successive contracts is an advantage for their keeping their bids low. If the past pattern of low bids does not hold up in the future, however, there will be upward pressure on the construction budget.

The situation involving the size and nature of the bidding pool needs careful monitoring on the part of project management, including measures to insure that incentives remain for contractors to bid competitively on the program packages yet to be awarded.

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[11] In the following discussion some figures may not add up exactly due to either variations in the office estimates or missing figures in the tabulations and also to the fact that some award prices were in one group while the office estimate was in another; however, the overall figures are approximately correct.

[12] Some federal agencies hold to a policy that requires a minimum of three valid bids in order for a bid opening to be considered valid; otherwise the contract is re-bid.

2. Bid acceptance policy

Of equal concern in the bidding process is the disparity some CA/T projects have experienced between the office estimate for a particular construction package and the price of the contract awarded, especially when the awarded contract is substantially above the office estimate. At present, we understand that there is no set policy within CA/T for bid acceptance. In the award of military construction contracts, it is common practice to set a limit on how much the low bid can vary from the office estimate. Quite often bids that vary by more than 10% from the office estimate are not awarded until the office estimate is reconciled with the bid received. The bid opening is put on hold, and the firm that prepared the plans and specifications reviews its cost estimate and the low bid submitted to detect any causes for the differences. If the differences cannot be successfully identified and corrected, the bid opening is canceled and the contract is re-bid. This process provides protection against runaway costs and the award of contracts that are excessive.

In the above listing of CA/T contracts, there are ten contracts awarded where the bid was 20% or more above the office estimate; in most cases, they were between 20 and 40% higher, with one of them 357% higher than the office estimate. Even contracts awarded at bids below the office estimate are significant since they often can be a harbinger of excessive change order demands later on. In the above groupings there are thirty-four contracts awarded at prices that were more than 20% bbelow the office estimate and another fourteen that were between 10 and 20% below the office estimate.

In view of the detailed and costly engineering efforts of the project management and the section designers to create solid plans and specifications, this situation appears to warrant careful evaluation with tightened procedures, if necessary. Consideration should be given before contract award to reviewing the reliability of the office estimate and the low bid on any contract that falls outside a 10% parameter of the office estimate.

3. The A-B bidding process

The Massachusetts Highway Department (MHD) wants to use an alternative method of construction bidding, called A-B bidding, as a schedule optimization measure on discrete CA/T project segments that interface and are on the critical path. The MHD believes they could do this under existing law, Chapters 30 and 149 of the Massachusetts General Laws. On November 6, 1996, the State Attorney General sustained a bid protest against A-B bidding on the grounds that Chapters 30 and 149 did not allow it; the Superior Court upheld the Attorney General's ruling.

In order to use A-B bidding, MHD has submitted a bill, H.117, that would authorize its use, as well as other alternative methods of construction such as design-build, turnkey, etc.[13] The bill directs

[13] The design/ build option - The laws of the Commonwealth governing public construction mandate that there be a clear cut "division of labor and responsibility" between the designer/engineer who determines the scope and specifications for a project and the contractor who builds it. This process involves some duplication of costs in the design process and sometimes prevents the designer from having the benefit of a construction contractor's knowledge of technique and the contractor from having the ongoing benefit of the designer's skills. This is a problem in a complicated project like the "big dig" where there are so many unknowns in the process of building underground in an old urban environment that it is hard for the designer to

MHD to procure a sufficient number of contracts using such alternatives to permit evaluation of their effectiveness in terms of time and cost savings. A report must be filed with the Joint Committee on Transportation and the House and Senate Committees on Ways and Means along with recommendations by June 30, 1999.

In A-B bidding, bidders submit the sum of items contained in the Schedule of Quantities and Prices as their "Total Estimated Contract Price" (Part A). Bidders also submit the number of days (between 0 and 100), prior to the contract completion date specified in the bid invitation package, within which they will complete performance of the work. The number of "saved" days is multiplied by a value calculated by MHD for each saved construction day to arrive at an "Adjustment for Days Saved" (Part B). The Adjustment for Days Saved is subtracted from the Estimated Contract Price to arrive at the "Proposal Price."

The bidder submitting the lowest Proposal Price wins the contract bid. However, the successful bidder will be paid the Total Estimated Contract Price. Should the successful bidder fail to perform within the time in the contract, he/she will be assessed liquidated damages for each saved day that is delayed or not realized. Under this bidding method, a successful bidder may not necessarily have the lowest Total Estimated Contract Price among the bidders. A-B bidding would be used only for work on the project critical path.

Saving days will save money. Money would be saved because the project that next interfaces can start earlier. No overall cost savings can be estimated, however, because there has been no public construction experience with A-B bidding in Massachusetts, although it has been used in other jurisdictions.

Several contractors who were interviewed strongly opposed A-B bidding because they believe it is vulnerable to fraud. In fact, Construction Industries of Massachusetts (CIM) was the plaintiff in a recent case before the Superior Court. The contractors argue that a contractor, in order to get CA/T contracts, will bid an unrealistic number of days saved. After winning the contract, the contractor will do anything to insure that failure to achieve days saved cannot be blamed on him to avoid liquidated damages. If CIM's argument proves to be true, no savings would accrue by this method, and, indeed, could cost the project and the taxpayer more. At this stage, however, there is no hard evidence to support this contention. Enactment of a new law by the Legislature is needed to authorize A-B bidding; it should be enacted as soon as possible, considering the considerable number of construction contracts to be let this calendar year.

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know what to specify in the designs and hard for the construction contractor to formulate a realistic bid. To solve this problem nationwide and to possibly reduce the costs of major public projects, the engineering/construction industry along with "public owners" have been using a new practice called "design/build" which breaks down this division of labor by allowing a construction project to accept bids from contracting organizations which will combine both the final engineering design and the construction in the same construction contract, thus saving costs in both the design and construction process. While this blurs responsibility somewhat and could remove from the owner the protection offered by an independent engineer/designer who can represent him during the construction process, it is being actively considered by many public agencies as a means of reducing costs on expensive public works project. For the CA/T program, the laws and practices of the Commonwealth did not allow this method to be tried and at this stage of the project with virtually all final designs complete, its use as a cost saving technique is largely academic.

Since CA/T management believes this would encourage bids which would help the overall project schedule and thereby save cost, it deserves consideration. A discrete test period should be authorized to disprove or prove the arguments for A-B bidding. The law should expire at the end of the test period, June 30, 1999. If test results prove the value of A-B bidding, the law authorizing the same could be made permanent.

4. Exemption from filed sub-bid requirements

The Ward Commission in 1980 recommended the repeal of the filed sub-bid law; however, their recommendation was never followed. **There are significant potential savings to the CA/T project if the Legislature suspends the filed sub-bid provisions of Chapter 149 as it applies to the project. The savings might be in the order of $10 million.**

Under Massachusetts law, the selection of sub-contractors on public construction of buildings (so called "vertical construction") must be done independently of the selection of the general contractor. This provision applies to sub-contractors involving some 17 different crafts, including electricians, plumbers, painters, installers of elevators, heating and air-conditioning and others. The subcontractors file separate bids which are opened two days before the general contractors' bids are opened. The general contractors must then select one of the sub-bidders. With essentially no time to check the sub-bidders qualifications and performance potentials and with their costs added to their own, the general contractors almost always select the lowest bidder. Thus, as a practical matter, the general contractor has no significant role in selecting subcontractors and little leverage in coordinating and enforcing the quality and timeliness of their performance.

Although most of the CA/T project involves "horizontal" construction (tunnels and viaducts) to which filed sub-bid provisions do not apply, the provisions do apply to the ventilation buildings required as part of the tunnel components. Because they are integral parts of tunnel construction and operation, there is no particular reason that they should not be included directly in the construction packages for the tunnels, except for the provisions of the filed sub-bid requirement. There are more vent buildings required in the CA/T project than in any other similar project built in the U.S. The need to accept filed sub-bids on these projects has already had a negative effect in project costs.[14] Of the eight called for in the plan, only three remain to be bid. Their estimated cost is $97 million. A reasonable estimate is that the filed sub-bid provisions will directly add about 10% to the bids for these packages. Massachusetts Water Resources Authority (MWRA) sought a similar exemption for the Boston Harbor project, after having the results of a study by Cambridge Systematics which estimated that from 7.5% to 11.5% would be added to the contracts to which the filed sub-bid provisions would apply. [15]

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[14] Project management reported that there have been the predicted difficulties with this procedure. Sub-contractors procured in this way often did not show up to work on their project, a situation which required the MHD staff to track down the subs and bring them to the work site. In other instances, the low bids received (for roofing and elevator installation, for example) were close to double the office estimates for the work and required substantial redesign and schedule delays . Had the bids been part of the prime contractor's responsibility, they would have been more in line with project requirements.

[15] In interviews with contractors, Cambridge Systematics found that they increased their bids by up to 9% on projects involving filed sub-bids. The bids are increased by up to 3% to account for the higher management costs (about 15%) of working with subcontractors with whom they have not previously worked to cover extra field personnel, extra meetings, and

In addition, there is a strong possibility that the work contracted by this method will contribute to potential schedule delays, particularly for projects on the critical path. Since the prime contractor with responsibility for the overall schedule, has little leverage over the subs (who are in effect hired by the "owner"), the completion schedule is often at the mercy of the subs who may demand more money (in the form of change orders) to keep to the prime's schedule. On a project with critical time pressures, it is much more efficient to have the prime contractor in complete control of the work schedule and performance as would be the case if the filed sub-bid procedure were not in force.

The filed sub-bid procedure is defended by subcontractors who fear that prime contractors will wait until they have a contract award, then use their considerable leverage to shop around for the best possible price. Many of the construction trade unions also support the system in order to protect themselves from the possibility of work being given to non-union subs. Since all CA/T contracts are covered by labor agreements that specify all work to be done at union wage rates, the fear of subcontractors being hired at below union wage is minimal. Nonetheless, there is a long standing alliance between some of the craft unions and the subcontractors to insure hiring their members, a situation which the filed sub-bid systems helps protect. Under the proposed plan union wages would still be paid, with the prime contractors controlling the process. However, they may not be held necessarily to the boundaries between crafts as defined by the craft unions.

The potential savings to the CA/T program from this exemption are possible only if the Legislature acts within the new few months to suspend the provisions of Chapter 149 as they apply to the CA/T project. (Such action has already been taken by the legislatures of Connecticut and New York which repealed their equivalents to their filed sub/bid requirements.) If such an exemption were also applied to the construction of the Logan 2000 plan, savings to the Commonwealth could be substantial. We recommend that the Legislature act to allow this exemption--at least on a trial basis--a move supported by CA/T management and the other affected agencies.

B. Construction contract management

This is an area in which the CA/T management, MHD, FHWA, and the oversight agencies have made a major effort since the beginning of the heavy construction period in the early 1990's. The project management team has tried to anticipate difficult construction situations by learning from the past. However, there are three interrelated policies and applications which are the most critical to the ability of the project to contain and possibly reduce costs. These are **partnering policy, change order policy, and value engineering change proposals policy**. All these are the responsibility of the program management team.

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more intense monitoring of their work. In addition, up to 4% is added to the bidder's contingency allowance to cover the problems of working with up to 17 different subcontractors, potential delays, disputes between the subs, resolving gaps and overlaps in work assignments and others.

1. Partnering policy

The construction industry has experienced an unprecedented growth in claims and litigation over the past ten to twenty years. Disputes inevitably involve the owners and their representatives (the project manager and section designers) and the many contractors and sub-contractors on the job. Conflicts also arise between general contractors and their subs. Unresolved disputes fester and grow into work stoppages, ultimately leading to litigation with consequent work slow downs and disruption of schedules, poor morale and, not surprisingly, poorer safety records. All these effects result in additional costs.

There are a number of techniques which can help reduce the costly effects of the division of responsibility among the owner-project manager, engineer/designer, and construction contractor. One that has been used extensively by the CA/T project is **"partnering"**, a method of putting the program manager and the successful contractor into a working relationship to avoid the confrontational disputes that result in costly claims and project delays. **Both project management and contractors credit the partnering program for the exceptionally low claims experience on the CA/T program to date.**

In 1992, the Massachusetts Highway Department (MHD) decided to try "Partnering" on the Central Artery/Tunnel (CA/T) Project, challenging all companies that were part of the project to pledge that they would promote cooperation among all parties for their mutual benefit.[16] In the CA/T project partnering, a concept meant to mitigate the typically adversarial relationship among construction parties, is incorporated at four levels:

--Contract Partnering
--Inter-Contract Partnering
--Internal Partnering
--Partnering with Community Groups

Contract Partnering involved bilateral agreements between Contract Management teams (FHWA, MHD, B/PB) and the Section Designers during the design phase of the project or with the General Construction Contractors during the construction phase. Third parties were invited to participate in each of these phases and included organizations such as MPA, MBTA, Sub-Contractors, etc.

Inter-Contract Partnering was initiated by the CA/T Area Construction Managers as a multi-lateral agreement among the Construction Contract Management Team (FHWA, MHD, B/PB), usually at the area management level and two or more general construction contractors working in confined or adjacent areas. Third parties may participate but generally the agreement is to focus the parties on ways to coordinate their work activities and to accomplish their respective contracts with minimum interference from one another. When applicable, normal construction Contract Partnering is used to interface with interested third parties.

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16 "Partnering" is an alternative for doing business where all the parties make long term commitments to achieve common goals. It was introduced to the construction industry by the U.S. Army Corps of Engineers back in 1988 and is rapidly becoming part of every major construction project undertaken in the United States today.

Internal Partnering has many forms. Most include the Contract Management Team (FHWA, MHD, Joint Venture), although some are limited to MHD-Joint Venture or to internal problems of the Joint Venture partners. In these cases, the purpose of these agreements is to improve and streamline the internal working relationships.

Partnering with community groups -- The policy of encouraging partnering among community and institutional groups, construction contractors, CA/T management, and MHD has resulted in benefits to mitigation. Since the mitigation measures are included in the construction cost estimate and bidding packages, there has been agreement in advance which has reduced the level of potential major change orders and claims. Some major contractors have been exceptionally receptive to working with community groups to accommodate complaints and maintain good will without holding up a contract or putting in immediate change orders. If this pattern continues, it will help cost containment efforts.

Construction contractors interviewed for this study indicated they felt they were dealt with fairly as a result of the application of CA/T's partnering policy. Although, in some cases, a contractor may not have liked the resulting decision or agreement, the opportunity to state his case was there. We were told by several contractors that all disputes had been settled without resorting to litigation. With over twenty five percent of the dollar value of construction completed to date, the fact that no dispute has gone to litigation is important.

There are some who argue that partnering agreements, while promoting cooperation and progress among contractors, are being accomplished by CA/T management leaning towards over generous claims settlements and that the project might be better off in terms of overall cost if some contractor claims were litigated .[17] There is some concern within CA/T management as to whether partnering does result in additional cost. Some believe the relationship is too relaxed. However, given the essential priority of the overall project schedule and the problems that delays caused by litigation on one contract could have on related interlinked construction, it is too soon to tell whether the partnering approach is causing unnecessary cost escalation. So far, progress is made and disagreements are amicably resolved so that construction is proceeding with minimal delay.

CA/T management estimates that a one day delay of a contract on the critical path is a setback worth approximately $800,000 to the owner. According to both management and the contractors, the priority put on the partnering arrangements plays a key role in preventing delays by avoiding job stoppages. It helps with the essential goal of the CA/T program to complete critical jobs on or ahead of schedule.

[17] Some senior management personnel of other Boston area authorities are known to have their reservations about Partnering. One commented, "I don't like it, it's like letting the contractor put his hands in your pockets."

2. Change order policy

Reducing the rate of change orders (expressed as a percentage of original contract bid value) represents the largest potential for costs savings within the CA/T project. With remaining construction amounting to about $4.0 billion, a reduction of change order costs of just from one half of one to one percent would mean potential saving of from $20 to $40 million.

Project management has established a target for change order allowances above the contract bid price of 10.7%. This target is reflected in the 1996 Finance Plan and has been approved by the FHWA. It represents an important reduction from the 24% that the project experienced on some of its earlier construction contracts. In response to concerns expressed by oversight agencies and to reflect the current project management effort on cost containment, a task force has been created by project management to focus on these issues.[18]

There are two major causes for change orders;

- **Unanticipated site conditions** -- a major problem in the areas where underground excavation and tunnel construction plans are being implemented in downtown Boston in the areas that were once part of the harbor and subsequently filled in and loaded with utility lines of different sorts.

- **Unanticipated mitigation measures** -- particularly those requested by agencies, businesses and community groups to protect adjacent streets and neighborhoods from noise, dust and vehicular and pedestrian traffic hindrances during the construction process.

While the extensive planning and engineering work anticipated most of these problems, which were reflected in cost estimates and subsequent contract bids, there will inevitably be changes once the construction process is underway.

There are a number of measures suggested by project management staff, by contractors, and others experienced with Massachusetts construction laws and practices, that can be examined and implemented by project management and others to help reduce the impact on the project budget by change orders.

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[18] The task force includes the senior managers in charge of construction for the Joint Venture, along with representatives of MHD and FHWA and the MHD Director of Design and the Construction Contract Administration Manager.

A "deductible" for change orders

To date the CA/T project has processed about 3,000 change orders. Of these, 91% have involved sums of less than $250,000, and half of these less than $15,000. A relatively few large change orders account for most of the money involved. The 9% of change orders over $250,000 account for 84% of the total change order cost.

Processing change orders involves costs not only to the project management staff but to the contractor as well, and delays can hold up the overall project schedule.[19] Eliminating the processing of smaller change orders (of $25,000 or less) could eliminate a significant portion of processing expense. By raising the limit to $100,000 (which represents about one-fifth of one percent of a typical CA/T contract), much more processing cost could be saved. This could be done by advertising future contracts with a clause which would make the contractor liable for the first $100,000 of any change order. The requirement would not only avoid processing costs but also provide an incentive for the contractor to perform the actual work for less. Change orders are now paid for on a pre-determined cost of time and materials basis [20] and are almost always completed before changes are finally approved. Switching to a fixed cost for the smaller changes should create pressure to get the job done quickly and efficiently and avoid problems caused by approval procedures. If some protection is needed for contractors with this procedure, a larger deductible of, say, $100,000 could be limited only to those claims initiated by the contractor himself. The claims for changes initiated by the "owner" could be limited to a smaller amount, say $25,000. It would also be possible to set a dollar limit on the absolute number of owner-initiated claims to which the exemption applies (for example, one claim for every $2.5 million of contract value). It is important that the deductible amount, at whatever level, be subtracted from the amount paid on all claims, including those that exceed the set limits, so that there is no incentive to elevate, for example, a $90,000 claim to $101,000.

There are unconfirmed reports that the U.S. Department of Defense has been experimenting with this approach with some success. In their case, all claims for changes up to 1% of total contract value are absorbed by the contractor. In the case of the CA/T project, it is possible that some legislation may be required (section 39N of Chapter 30). CA/T project management is working on specific proposals

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19 One CA/T resident engineer visited by our team had 92 change orders to date in his project, of which 73 were contractor initiated which amounted to less than $300,000 on what will be a $70 million job. The remaining 27 were valued at about $5.0 million. However, the time and effort required to process both the large and the small claims were not in proportion to the sums involved.

20 The use of pre-determined unit costs for required changes has generally been popular with the construction contractors for it allows them to bid a contract with a good notion of how much they can be paid for unanticipated changes. However, there is often a great deal of complexity in auditing the quantities involved, and there is some incentive for contractors to under bid the unit costs of items they think will be used in smaller quantities than contained in the office estimates. If more quantity is needed, the argument is for "changed conditions" and unit prices in excess of those bid are sought. This situation undercuts the "ease of administration" rationale for unit cost changes. The use of unit cost requires the contractor's honest application of the unit price provision. In many contracts bid as lump sum (L.S.), it is often necessary for the owner to go back to the low bidders and request unit prices to help the owner when making progress payments. In contracts bid with unit prices, bids submitted using unusually high or low unit prices in hopes of making a "killing" are termed "unbalanced bids". It is usually the responsibility of the office reviewing the bid prices – in this case the Section Designer – to detect this "unbalance" and to reject the bid when it appears purposely designed to "make a killing." Contracts bid with honest unit prices are easier to administer and end up saving money for the owners.

in this regard which we believe should be given support.

Unit pricing generally saves time and effort in processing change orders by making it an up front element of the contract bid. The deductible concept should be tested before being applied across the board.

Other administrative measures

There are other measures noted by project management, construction contractors, and others which could improve the change order process. These include the following:

- **Strengthening contract language** -- by stating contractor responsibility with more precision, removing clauses related to general desires and not to specific results, and consolidating sections with overlapping requirements. This language is reviewed annually by project management based on experience and should help tighten the change order process.

- **"No damages for delay" --** The standard CA/T contract allows for the recovery of additional money, as well as time, for those delays caused by the "owner" (MHD). While Massachusetts law allows public agencies to include clauses which allow contractors to have additional time for delays not caused by them, but without more money, this provision has not yet been used by CA/T. Given that the project now has a track record of experience on which to build contractual requirements, this type of provision might well be considered.

- **Optimizing the benefit from contractual provisions** -- The project's Change Order Task Force is tightening the directions given to resident engineers to undertake more stringent enforcement of material, technical, and safety requirements of specifications and to ensure that contractors are meeting their required quality control responsibilities, as well as notice of claims, proposal submissions, and document requirements. In this context, they have been instructed to consider "the most reasonable" interpretation of contract provisions, rather than to accept, in general, the contractor's position if it was reasonable. Now accepting the contractor's position will be done if it is the "most reasonable" interpretation of a specific provision of the contract.

- **Improve the independent assessment process --** In the final analysis, the estimate of what a change order proposal is worth rests with the independent assessment prepared by the CA/T project control staff. However, the Field Contract Administrator also prepares an assessment. In instances our team had a chance to review, the assessment coming from the Field Administrator (often with better knowledge of the specific situation) was about twice as high as that of the independent assessment. This situation makes it difficult for the project to have a unified position vis-avis the contractor in final negotiations over the change order value. Clarification of the communications links in this procedure should help the quality of the resulting decisions.

- **Simplify paperwork requirements** -- In our discussions with contractors, one consistent complaint involved the volume of paperwork they were required to prepare to document change order requests. To contractors, it appears that there are too many people in project management required to handle and sign off on change orders. Project management is currently taking steps to improve this situation, to reduce costs both to the contractor and project management. One of the construction contractors interviewed said that he was "drowning in overhead." He stated that on one specific job he had to add thirty (30) persons to his staff to handle the paperwork and manage the interchange of schedules, meetings, etc. that he or others on his staff were required to attend or participate in to meet contract requirements. These are thirty persons who do not do any of the required construction work, but do only the required paperwork called for under the contract.

3. The Value Engineering Change Proposals Policy

During the period of the work on final engineering design from 1991 through 1995, project management also instituted another cost reduction technique called "value engineering". This method required final design engineers to hold to a specific construction budget once their designs have reached 75% completion, then submit the designs to a peer review panel which reviews them for possible cost reduction. Project management claims that this process produced important savings of close to $500 million[21] in the specifications for the construction packages (See table 3.3).

Table 3.3 - Savings from Value Engineering To Date

Value Engineering	No. of Recommendations	Total Savings $K
Design Phase	27	477,880
Construction Phase	63 (to date)	13,000
Total		490,880

In the construction phase, Value Engineering Change Proposals (VECPs) provide an opportunity for the construction contractor to submit ideas for cost savings and for acceleration of a construction project, and to share in the cost savings with the Commonwealth, often on a 50 - 50 basis. To be effective, a VECP program must be fair and comprehensive in its review and speedy in its execution. According to the U.S. Army Corps of Engineers, a good VECP program should be capable of realizing an overall savings of 6 to 8 percent of the project construction cost. With $4 billion in construction remaining to be put in place, savings can amount to more than $200 million dollars, half of which would be returned to the owner (MHD).

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[21] It should be noted that a number of the oversight agencies including the Commonwealth's Inspector General and the Federal GAO have been critical of the CA/T value engineering program, claiming that more savings might have been achieved for the Commonwealth if more VE proposals had been adopted before construction contracts were let.

There are a number of important characteristics of this procedure:

- By submitting a VECP, a construction contractor expects the owner will consider approving a modification in the project specifications, construction materials and/or techniques with the belief that such changes will improve the overall project, reduce costs and possibly speed the completion of work.

- Construction contractors can profit both in time and in dollars by submitting and executing workable VECP proposals. VECPs can enhance a construction contractor's reputation when, having submitted one or more executable VECPs he/she shows superior construction skills, higher productivity and a creative approach to constructing facilities and produces a better, more durable facility with lower life cycle costs.

- While there is no real opposition in principle to an effective VECP program, there is the potential for professional friction in its execution. The Section Designers who develop plans and specifications can be embarrassed when a VECP raises the question of why the section design did not anticipate the solution in the first place. There is always the possibility that VECPs will point out a limited and unimaginative design approach and/or a reluctance of a design firm to accept new design and construction approaches. If good VECPs are rejected for these reasons, then the project and the owner suffer and incur the burden of the costs which could have been saved, the time that could have been saved, and the improved quality of the facility that could have been constructed.

Central Artery/Tunnel (CA/T) managers report that, with about one quarter of construction contracts completed to date, overall VECP savings on 63 VECPs submitted through March ,1997, total about one half of one percent (or about $13 million). This relatively low amount of savings was explained in interviews with representatives of construction firms and officials from the Construction Industries of Massachusetts (CIM); they attributed the poor recovery to problems and complaints to the makeup and procedure of the VECP program.[22] Contractors submit preliminary proposals to the Resident Engineer outlining the idea (with as many drawings as necessary to illustrate the proposed change) and the potential cost savings. If the Resident Engineer believes a proposal is worth further consideration, he may ask that the VECP be developed further by the construction contractor or, if he feels unable to make a preliminary evaluation of the merit of the proposed change, he may send it on to a higher level of review.

Usually, the latter process applies. If the higher level of review sees the worth of the proposal, the construction contractor can enter into an agreement with project management for sharing design and other costs necessary to prepare a fully developed submission or, in some cases, costs may be paid fully by project management. However, the amount of detail required, according to contractors, and the number of times that additional information is requested by the review team, is so great that much precious time can be consumed -- and the contractor cannot stop his operation while evaluation proceeds. [23]

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[22] CA/T VECP procedures were criticized earlier by the Massachusetts Office of the Inspector General (IG) in its report "Value Engineering Change Proposals: dated December, 1996. As a result, the Massachusetts Highway Department, through its Project Manager issued Revision 5 to the CA/T "Project Procedures No. 1213." Because there was an interactive exchange of findings and recommended actions between the IG and the Project Office, the Project Procedure (PP) was issued and became effective on June 6, 1996 before the IG report actually was distributed. Although this Project Procedure corrected many of the older problems with the VECP program, the system remains complicated and is not yet completely effective

Some contractors believe that section design representatives on the evaluation and review team often hesitate to approve a VECP because it may reflect poorly on the section designer. " If it was any good it would have been included in the plans and specifications" and, " it will embarrass us if we go along with it because we didn't think of it" is what construction contractors believe underlies prolonged reviews and rejections by VECP committees. Sometimes the concern is understandable, especially when a section designer has no experience in the area where a change is proposed. [24].

In some cases, section designers have been accused of deliberately changing plans and specifications and issuing change orders when a VECP has been submitted so as to avoid approving the VECP, and thus render it no longer viable. The excuse usually is that the designer was never happy with that particular part of the design and now has had the opportunity to correct it. This deprives the contractor of his share of the savings, and also eliminates any potential savings for the State.

To turn a VECP program which looks, "great in the written regulations, but poor in execution" into an effective money saving measure requires the following actions:

- Encourage the submission of VECPs by simplifying the VECP submission and evaluation procedure.
- Reduce the number of personnel on the review panel and insure that review board members have authority to approve or reject the VECP.
- Use the engineering resources in the project management team to obtain expertise quickly in new techniques or material proposed by the VECP when the review board is lacking in these areas.
- Insure that any VECP submission can be evaluated in 30 days to insure that a contractor has the opportunity to implement the VECP without unduly delaying other parts of the contract.
- Sensitize project management to insure that designer pride and embarrassment are not reasons for rejecting a VECP.
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[23] Construction contractors say that, in many cases, the benefits of their VECPs have been lost in the time necessary for management to review the VECP. Contractors have frequently told management to disregard the VECP that was in the review process; "we (the construction contractor) are no longer interested in pursuing the change." This happens when the contractor proceeds with his construction contract beyond the point where the VECP had to be initiated; beyond this point some of the new construction must be removed before the proposed change can be started; consequently the benefit of the proposed change is lost. One contractor indicated that he intends to avoid submission of VECPs through the remainder of his contract because he has at least seven VECPs that have taken 6 months to a year or more to evaluate. Another construction contractor, commenting on the number of people involved in the review, claimed that many of the personnel involved had little authority to approve or reject the proposal under consideration. He claimed that where he has seen an effective VECP program, it has been conducted speedily and efficiently with a review and evaluation team of not more than eight (8) persons, each of whom had the necessary authority to move the proposal along. He said, "everybody knows that you can make progress more quickly with a committee of 5 or 6 persons rather than a committee of 20 to 30."

[24] In one of the VECPs submitted, the section designer apparently had no experience in "The New Austrian Tunneling Technique;" however, both joint venture firms participated in demonstration programs sponsored by the Department of Transportation on the Harvard Square Red Line extension in the 1970-80's where the applicability of the tunneling technique was proven. This is a case where the Project Management could have stepped in, and with their firms' superior knowledge of this relatively new construction technique, assumed the expert's role and quickly approved or rejected the procedure submitted.

From our discussions with project management and contractors, it appears that a review of\ current practices involving the VECP program is in order. Within the partnering policy of CA/T, a group composed of members from project management, section design teams, and construction contractors should meet quickly to resolve problems or misunderstandings involving VECP submissions so that contractors' faith in an honest, fair and speedy review of a proposal could be restored. Some construction contractors who vowed never to submit another VECP might again submit timely and cost saving ideas on this project. .

C. Environmental assistance

In conforming to the legal and regulatory requirements of federal and state environmental laws, the CA/T project has uncovered a number of areas in which assistance from the environmental regulatory agencies could help contain and reduce construction costs without violating commitments made to conform to applicable laws and regulations. Three of these have come to our attention through discussions with project management and contractors:

1. Review process relief

There are a number of actions required after required permits have been received for construction which may not be necessary to insure proper environmental protection. However, they impact the construction schedule which is the critical concern at this time. These include notifications of minor project changes over which there is confusion as to the applicability of MEPA regulations, reviews required under coastal zone management regulation already included in other agency's reviews, flexibility in the application of air quality regulations, exemption of large scale projects from inapplicable wetlands and waterways regulations, streamlining the surface water quality permit process, and others.[25] Use of these regulations to create often frivolous appeals can cause great problems in maintaining the construction schedule projects, including the CA/T program, with consequent additional costs.

2. Soil handling definitions

Construction contractors working on the CA/T program have been delayed by requirements for handling "contaminated" soil which is excavated from construction sites, but then is "decontaminated" if used as fill when tunneling construction is completed. They point out that their need to provide "uncontaminated" fill for an underground site in which the leaching process of adjacent soil provides the same level of "contaminants" as the soil extracted is not particularly efficient. Since the sites are underground, the higher quality soils for fill are not necessary for environmental protection. Contractors believe that more functional definitions of soil qualities and their use would help them perform at lower cost. This appears to be an appropriate issue for study by the agencies involved.

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[25] These issues are discussed in detail in a letter and memorandum to the Assistant Secretary of the Executive Office of Administration and Finance by the General Counsel of the Executive Office of Transportation and Construction of December 11, 1996 concerning Executive Order 384.

3. Additional landfill sites

Since the handling of excavated material from the CA/T tunneling operations has become a larger and more difficult logistical issue than originally anticipated, project management needs the assistance of the environmental agencies – both state and federal -- in locating sites for additional landfill operations. There could be significant savings available to the project if the Department of Environmental Protection can develop procedures which encourage lower bids on the disposal of materials to allow for the depressed Artery roadway. Possible savings are in the order of $5 to $30 million.

Soil displaced during the construction of the Artery is historic fill -- material put into the harbor over 100 years ago to expand downtown Boston. While this material is not a hazardous waste, it is not exactly pollution-free. There are a variety of sites where the material would be useful and safe, particularly if some kind of cap is put over it. For example, it could be used under a roadway, or, as proposed for golf courses, used to convert a flat area to one with gentle rolls and interesting contours, capped, with grass growing above the cap. Because the material does contain some contaminants, case-by-case review of proposed sites would be more acceptable than blanket approvals in advance. The Artery will run out of existing disposal capacity in August, meaning that the first of the disposal contracts must be put out to bid in June. Estimates of the cost for disposal at in-state locations is roughly $20 per cubic yard, while out-of-state disposal may cost about fifty percent more ($30 per cubic yard). Since approximately 4.7 million cubic yards are involved, using in-state sites could yield savings of up to $25 to $30 million.

The chief obstacle to realizing these potential savings is in the Department of Environmental Protection (DEP) site approval process (which in the past has ranged from several months up to several years). An accelerated review process or even pre-approval of a few existing landfills could provide potential bidders with the assurance that there will be a quick, reliable process for approval of additional in-state sites. The inter-agency staffing agreement between the CA/T project and DEP may already be sufficient to cover the cost of additional DEP staff for this purpose. [26]

D. Other Measures

1. Police details

Police details are a significant cost to the CA/T project, a cost which is borne by the state alone. The cost to-date is over $22 million and is expected to total nearly $75 million by the end of the project in late 2004.

Some presence is required to direct traffic around the many construction sites of the project. Professional police are used in Massachusetts while, in other jurisdictions, flagmen or some other less expensive method of handling construction traffic is used.

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[26] Opposition to expedited decision making on disposal sites from the environmental community is likely. Groups who viewed the lengthy approval process as a safeguard against possible abuse, or parties with business before DEP who feared that expedited action on Artery project requests might further lengthen delays in dealing with their own projects might voice particular objections. Arguments against expedited action would likely allude to fears that the state would be influenced by the potential savings and would sacrifice environmental protection in order to save money on the CA/T project.

Project management has negotiated an arrangement with the City of Boston and its police unions which requires a sergeant with every two patrolmen—the sergeant stands a post for each CA/T site with the detail work centralized under a captain. This is a compromise from the usual system that would have had a sergeant for each three patrolmen, and every two sergeants requiring a captain. The latter would have cost over $120 million. The compromise first meant a cost estimate of about $80 million. The estimate has been further reduced to about $75 million through a better understanding of construction staging.

Management argues that an urban environment requires a professional police presence at a construction site. Moreover, they argue, flagmen cannot act in a remedial or preventative traffic situation. Thus, they conclude that the "myth that flagmen are cheeper (sic)" is not always true, that, with union wage structures and overhead, their cost "approaches" those of the professional detail.

Others would argue that flagmen costs may approach those of a professional detail, but they are still far away. The federal government used to participate fully in sharing, but gradually reduced its share of these costs. After some controversy, there was voluntary agreement that the state would be responsible for full costs.

2. Insurance Program

The CA/T's risk management or insurance program is one of the success stories of the project thus far. Built on a successful and effective safety program, luck, and good owner-contractor relationships the insurance program is expected to realize substantial credits by project's end.

The Massachusetts Highway Department (MHD) undertook a risk assessment in 1991 to determine how to manage and insure the project's risks until completion. Its decision was to undertake an owner-owned or wrap-up insurance program in 1992 that they believe would be easier to manage, more productive and more cost effective than insurance purchased by each contractor and sub-contractor.

The insurance program includes six different coverages; the largest and most expensive are Workmen's Compensation (WC) and General Liability (GL). The former covers workers and the latter third parties. The two programs account for about 90% of the premiums paid with WC responsible for about two-thirds of premiums.

Total premium payments from 1992 to the end of the project are expected to total about $780 million; close to $300 million has been paid to date. The actual or net cost of the program by project's end should be about $150 million, however, provided current projected loss ratios and other assumptions are realized.

Current loss ratios, a function of losses and premium payments, are far below the expected loss ratio of 55% and the 75% upon which the initial policy was based. Current WC loss ratio is 30% and the GL loss ratio is 12%.

The state makes regular premium payments into a trust fund designed to cover anticipated losses. The trust fund has two loss accounts that are used to pay claims filed during construction. Annual interest earned on these accounts is shared equally between MHD and the insurance carrier. A third account, recently established, is MHD's retained earnings account into which is transferred MHD's share of annual interest generated by the two loss accounts.

The retained earnings account is expected to total about $350 million by 2005. Retention of that amount and its successful investment until 2018 when the claims period should end is projected to generate about $600 million.

It should be pointed out, however, that the current loss experience has taken place in a period when only about 30% of construction has been completed. Remaining is the complex and difficult downtown construction with its higher risks. Higher loss ratios would lower the program savings from the expected $600 million. For the project to realize its optimistic scenario, it will have to ratchet up the intensity of the safety program and continue to enjoy the same degree of luck.

3. Approval of plans for vertical construction

Chapter 11 of the Acts of 1997, adds CA/T vertical construction to the definition of capital facilities which are exempted from the Division of Capital Planning and Operation (DCPO) jurisdiction.

DCPO has the statutory authority to review and approve or disapprove the plans and specifications for all public building construction by the state. The items included in each section of the Plans and Specifications are such that the buildings which contain them are generally termed "Vertical Construction," or buildings generally intended to be occupied. This contrasts with construction authorized under Chapter 30 of the General Laws termed "Horizontal Construction" or more commonly, highway or heavy construction.

The CA/T Project contains a number of facilities which can be classified as vertical construction and which normally would come under the jurisdiction of the DCPO. These are:

--The ventilation buildings
--The parking garage (at Parcel 7) which has retail space at grade and some office space.
--The operation and control center
--The back-up to the operation and control center
--The toll plaza
--Emergency Stations (4 each) where tow trucks are in readiness
--The central maintenance facility in South Boston
--The satellite maintenance facility
--One or two electrical sub-stations
--A visitors' center on Spectacle Island

The DCPO has the statutory authority to control and supervise the planning, design and construction of public buildings, except for projects which the Legislature has exempted from DCPO jurisdiction.

The DCPO and the Department of Public Works (DPW), now the Massachusetts Highway Department (MHD), developed an agreement in August 1990 in which the two agencies agreed to certain inter-agency procedures certificating of planning (within 21 days), approving of the MHD procurement procedure for the selection of a final designer, management of the final design (within 21 days) and resolution of disagreements (within 10 to 15 days). The plans and specifications cannot be advertised until they are approved.

In 1994, Section 11 of Chapter 102 of the Acts of 1994 (the Transportation Bond Bill), specified MHD jurisdiction over design of the CA/T project ventilation of buildings, utility facilities and toll booths subject to prior review by the Inspector General.

The 1996 transportation bond bill expanded the IG's responsibility to include review of construction as well. The Inspector General has since conducted reviews of a number of facilities (See IG publication: "Statutorily Mandated Reviews of Central Artery/Tunnel Projects Building Construction Contracts" dated December 1996), and concentrated on:

--Cost Containment
--Cost and Design Changes
--Change Orders/Value Engineering
--Mitigation Agreements
--Federal Funding

In effect, DCPO has no role in CA/T construction while the Inspector General (IG) does.
It would appear that the IG's staff may have neither the number nor the variety of engineering personnel needed to review and approve plans and specifications for the CA/T project. The Inspector General's responsibility and expertise is in the area of detecting and preventing fraud, waste and abuse while the DCPO's is in planning, engineering, design and construction. Thus, it appears that the Inspector General's office has been assigned a responsibility in an area where it may not be qualified to perform.

CA/T management should evaluate the impact of this transferred authority to ensure that the Inspector General's new authority does not additionally delay the review and approval of plans and specifications and therefore slow down the completion of the CA/T project.

SUMMARY OF COST CONTAINMENT/REDUCTION ISSUES IN THE CONSTRUCTION PROCESS

As we have discussed, there are a variety of measures which are being and could be applied to help in containing and reducing CA/T costs during the intense period of construction now underway. These are summarized in Table 3.4. While many of the most important measures are the responsibility of CA/T management, others will require the active support and cooperation of the Legislature and other state and local agencies. With each area of potential cost reduction having a "constituency" whose interest may be affected by any change in existing practice, there is no guarantee that implementing any or all these measures will be easy. Nevertheless, it is in the interest of the Commonwealth and its taxpayers to see that as many of these measures as possible can be tried, tested, and implemented as the program moves ahead. Without a cooperative effort on the part of all the "parties at interest," including a more active role on the part of the Legislature to monitor and assist in the process, the potential for increased project costs will be high.

Table 3.4 - SUMMARY OF CA/T CONSTRUCTION COST ISSUES

SUBJECT	FINDINGS	POTENTIAL COST SAVINGS	RECOMMENDATION
BID POLICY			
Bidders list expansion Bid acceptance	Concerns with the small number of bidders on large contracts and the procedures for accepting bids varying from office estimates	Not easy to determine, but could be a problem with new bids higher than office estimates	Monitoring of bidding process is required to determine if action is needed
A-B bid procedure Filed sub-bid exemption	Legislation needed to take advantage of possible cost savings	Limited but possibly important	Proposed legislation is justified and allows CA/T to experiment with these approaches
CONTRACT ADM'N			
Partnering Policy Change Order Policy VECP Policy	These should be the most effective way to control or reduce costs as the large construction contracts are let.	Could range from 3% to 4% of remaining contract values with effective handling of these techniques	Streamline review and approval system-- Experiment with "deductible" for change orders -- Encourage submission of VECPs
ENVIRONMENTAL ASSISTANCE Review relief Soil definitions Additional landfill sites	Construction process is uncovering problems which cause additional cost	Savings in soil handling policy could make a substantial difference in costs to complete	Cooperation from DEP and other relevant agencies should be encouraged
OTHER MEASURES			
Police details	These costs have been disallowed by the FHWA for Federal funds participation, so that the State has to pick up these costs	Millions now spent on this function, which has strong support from the Police unions, could be reduced .	Legislation is required to change police details policy -- reexamination of Legislature's position suggested.
Insurance Program	Wrap-around program has played an important role in keeping CA/T budget on target	Very large potential budget saving are evident with low accident experience	Monitoring of insurance claim experience suggested to determine future action.

CHAPTER 4 -- COST CONTAINMENT/REDUCTION IN PROJECT MANAGEMENT

The cost of managing the design and construction of the Central Artery /Tunnel project has been a prominent part of the overall budget. About $ 2.6 billion, or over 25% of the budget, has been allocated to these functions.[27] Because of the tremendous size and scope of the project, it was decided early on that the design and construction process could not be handled by the MHD, the agency normally responsible for managing highway building projects in the Commonwealth. As a result, the assistance of an outside construction management firm was sought through the competitive bidding process. In 1985, the Joint Venture of the Bechtel Corporation, one of the world's largest and most reputable construction management firms, and Parsons Brinkerhoff Quade and Douglas, a large engineering firm with extensive experience in tunneling projects in urban areas, was selected and has been responsible for project management ever since.

From 1988 through mid 1996 (which was the intense period of engineering of the project), the total cost of the design and management services averaged over $20 million a month, or 43% of the total project costs incurred during this period. This expenditure, while large, bought the project the hundreds of required approvals from environmental and funding agencies, the agreements on how the project was to be built and mitigation measures to be included in the design and construction bid packages. While some observers feel this amount of design and management expenditure was excessive, others viewed it as necessary to resolve all the complicated engineering and community related mitigation issues the project engendered.

Table 4.1 -- PROJECT MANAGEMENT AND DESIGN COSTS THROUGH MID 1996

PROJECT MANAGEMENT (includes preliminary design)	PROJECT FINAL DESIGN	COMBINED DESIGN AND MANAGEMENT
$1,300 M - 1988 to 1996	$ 800 M - 1989 to 1996	$ 2,100 M - 1988 to 1996
$ 12.04 M/month for 108 mo.	$ 8.33 M/month for 96 mo.	$ 20.36 M/month for 96 mo.

Source: MHD financial plan of 9/96 and summary project master schedule

The MHD financial plan of September 1996 estimated that $506 million would be required in the management budget for the period June 1996 to January 2000, and $179 million for final design activities (principally for surface restoration of the Artery and connections once the tunnel construction is complete). This final design work is scheduled to be completed before the end of 1997. The management costs will be used mainly to supervise construction contractors as they move through the

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[27] This figure includes $1.632 billion for the Joint Venture which covers both the preliminary engineering design work and management of both the design and construction process along with $1.028 billion for final section designs carried out by other engineering contractors under the supervision of the Joint Venture. This is a significant allocation of total project resources. Other mega projects, admittedly less complicated than the "Big Dig", have been able to be completed with a much smaller allocation for engineering design and project management. For example, of the total cost of close to $3.0 billion required to construct the Denver International Airport, roughly only $300 million, or about 10% of the total was needed to purchase the services of outside project management and design firms. However, it is important to point out that Denver created an integrated project management team which included a number of the City's own employees working side by side with the outside contractors.

building process. The CA/T management report of January, 1997, however, indicates an estimated management budget requirement of $ 638 million for the period up to the year 2000[28]. The $638 million includes an amount of $210 million needed beyond 1999. (Appendix A, P.17)

As the project moves into its final construction stages, it will be important for those responsible for its supervision to explore the possibilities for functions now planned for the management consultant to be absorbed by the agencies which will have ultimate responsibility for operating the system, particularly the MHD and the Massachusetts Turnpike Authority. **With the passage of the Metropolitan Highway System legislation, the Turnpike Authority will be thrust into a new and expanded role in the transportation picture of the region, a role that will require a major transformation of the agency into a first class system provider with expanded scope and quality of operations.** In this context, the expanded role of the Authority and the MHD should provide the opportunity to transfer some of the CA/T management functions to these agencies as appropriate.

We have made a preliminary assessment of this potential for cost savings by reviewing the costs, staffing structure and functions contained in the current work plan (Work Order 14) as well as the Project Management Plan of 12/31/96. **The results of this review are presented for possible exploration by project management and the appropriate agencies, not as definitive recommendations at this stage.**

The contract for management services, which includes both the Joint Venture and their subcontractors, has three elements of cost: direct costs, which are essentially the salaries of the employees working on the project; indirect or overhead costs; and a management fee, which in the case of the CA/T contract is 11% of the total of all direct and indirect costs. In the current work plan, the services of the Joint Venture firms account for about 85% of the budgeted costs and subcontractors 15%. This work plan covers about 900 staff positions covered by the management contract. In general, there are two categories of possible savings: the first is eliminating a function or position; the second is transferring a function or position out of the management consultant's
budget to that of one of the state agencies, thereby reducing part of the overhead costs associated with the management contract.[29]

The overhead rate for the staff of the Joint Venture is in the neighborhood of 110%. If a position for an employee with an annual salary of $60,000 is eliminated, the savings potential is over $145,000 per year ($60,000 in direct costs plus close to $66,000 in indirect costs and a fee of $14,000). If the position is transferred to a state agency, the savings might be in the order of $ 60,000 to $80,000 per year depending on the amount of non-salary expense associated with the agency position. The annual cost savings for a position with a salary of $75,000 are in the neighborhood of $175,000 if the position is eliminated entirely or up to $80,000 to $100,000 if the position is transferred. With a work force of about 900 people currently on the payroll of the Joint Venture, a reduction or transfer of from 5%

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[28] An additional $244 million for management costs has been identified as needed for the period from 2000 to 2002 (the original end of the project). This amounts to a total of over $800 million to close out the construction program.

[29] While it can be argued that there are overhead costs associated with state agencies, they are usually not at the same level as those associated with a private contractor.

to 10%, or just 45 to 90 positions, could engender important savings. The CA/T project management team is currently working in this direction.

There are three areas of potential cost savings which should be explored by CA/T management:

1. **Duplication of functions** -- a situation where one part of the management consultant staff is carrying out functions also being handled by another part or by MHD or another state agency.

2. **Community relations activities** -- particularly those related to the ongoing functions of the MHD and the Turnpike Authority which will be responsible for operating the Metropolitan Highway System when completed.

3. **Non-essential functions** -- particularly those which may not be required for project completion in a cost containment environment.

1. Duplication of functions

There appears to be some potential duplication of functions among various sections of the management consultant's team, as described in the current work plan, [30] and MHD and other state agencies. Some of these may be essential and justified, but others might be reviewed to determine whether some overlap can be eliminated.

- **Right of way activities** - The MHD has a full time, experienced Right of Way Bureau. Given the relatively small amount of right of way activity left in the CA/T program, could this activity be turned over to MHD? These activities include preparing preliminary plans, preparing easements, spot takings, land management, and legislative support (See Work Order 14, page 5).

- **Geotechnical support** --This is provided for in the current work plan as a support to design and construction activities, but does this overlap with the activities of area design and geotech consultants? (See Work Order 14, page 5)

- **Coordinating with Federal, State, and local agencies** -- The work plan describes this as a function of the management consultant in coordinating the activities of 30 different agencies. Is there some level of this coordination that might be handled as well or better by the staff of EOTC or some other permanent agency? (See Work Order 14, page 7)

[30] See Work Order 14 -- page references as follow.

- **Fiscal Management** -- There is provision for a fiscal management function within the management consultant team. Since the development of funding strategies and coordination of contract status are also carried on by EOTC and other branches of the state government, is this function still required in the program of the management consultant? (See Work Order 14, page 15)

- **Staff support functions** -- In the functions of the management consultant, there are some categories of support which might represent duplication. For example, there are positions for a director of communications and a director of media relations. Both of these functions are included in the staffing of other state agencies, including the Turnpike Authority, MHD, and EOTC. Is it possible to combine and/or reassign some of these activities to the permanent agencies, particularly since they are on-going functions of these agencies ? Does the management consultant need to have a legal librarian when MHD has a legal staff? (See Work Order 14, page 21)

- **Communication and contract administration** -- There is a function in the current work plan for servicing the Freedom of Information Act and audit information requests. There is also a function for a communications/ records management responsible for documentation. Would it be possible to combine the units responsible for these functions to save staff expense? There is a subcontracting unit in the Procurement function and a contract administration unit, both charged with relations with Joint Venture subcontractors. Could these functions be combined? There is a Prime Contract Administrator as a stand-alone position whose only function appears to be administering the contract between MHD and the Joint Venture. Is this a function that needs a separate position in light of the contract administration functions in the procurement and contract administration units? (See Project Management Plan, pages 31-33)

- **Construction management** -- There is a construction support department responsible for processing VECP proposals. The same role is performed in part by the resident engineers and the area construction managers. Is there some overlap in these functions the elimination of which could reduce staff costs? There is a technical support manager responsible for forecasting, training, etc, .and a projects control group with responsibility for estimating, scheduling and training. Are there some savings possible in this area? (See Project Management Plan, page 36)

2. Community relations activities

While recognizing that community and external relations are extremely important to ensuring the successful completion of the project, there will be a time when these activities should be transferred from the CA/T management to the permanent agencies and consolidated with their ongoing functions. Among the most important of these now handled under the management contract are:

- **Community outreach** -- The human resources function includes outreach activities for affirmative action and community based organizations, along with the clearinghouse for these organizations. (Work order 14, page 13)

- **Community relations** -- The public affairs function covers extensive community relations and external affairs activities (Work order 14, page 19).

- **Community participation** -- The architectural design services function, now primarily involved in the planning for the reuse of land in downtown Boston with the removal of the elevated Central Artery structure, is a function of the management contract (Work order 14, page 5).

- **Small business assistance** -- This service, which includes technical assistance and marketing, is also covered under the management contract (See Project Management Plan, page 9).

In order to contain and reduce CA/T management costs in these areas, it should be possible for EOTC, MHD, and the Turnpike Authority to work out a scheme for absorbing some of these functions into their existing public affairs, community relations and human resources operations in a way that would help relieve the budget burden without affecting the overall performance of the CA/T construction program.

3. Non-essential functions

As cutting the cost of program management becomes a priority as a cost containment/reduction measure, there are other areas currently contained within the scope of the management contract which might be examined for their priority in the management budget. These include:

- **Temporary agency administration --** The recruitment of temporary staff used by the project is now handled by an outside contractor. With a downsized management operation, is it possible to handle this function internally? (See Work Order 14, page 13)

- **Senior management functions --** The activities of the Board of Control of the Joint Venture are covered in the management budget. The positions of executive assistant and administrative assistant to the Program Manager are also covered. In a cost containment environment, are there some cost reduction potentials in these areas? (See Work Order 14, page 19, and Project Management Plan, figure 5.2)

- **Use of large task forces --** We have noted the observations of a number of the participants in the CA/T program of the use of relatively large task forces by project management to address critical issues, solve problems and develop policy. While the use of task forces is essential to good project management to provide broad perspectives on problem solving, for team building, and for quick resolution of issues, the amount of time required by key staff to participate in large meetings could detract from the performance of their primary functions. Without reducing the substantial benefits gained from the use of task forces, could their size and number be contained to prevent the poor use of key managers' time?

CHAPTER 5 -- FINANCING CA/T

While the political, environmental, and transportation management contexts have remained relatively unchanged since the construction program of the CA/T program began in 1991, the financing context for the project has changed significantly.

During the time that the project was being conceived, the Interstate Highway program was in effect and was assumed to provide the basis for the funding. This program provided federal government reimbursement for 90% of the costs of construction for the parts of the projects on the Interstate system. While most other states were able to complete their elements of the program before its expiration, the length of time it took to plan and construct both the I-90 and I-93 segments of the CA/T project meant that Massachusetts could not complete the construction before the termination date. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), which provided for the continuation of the use of highway trust funds to finance the completion of interstate highways, was to end completely by the mid 1990's.[31] ISTEA funding will expire at the end of the current federal fiscal year, September 30, 1997. Replacement legislation now being shaped in Congress, amid increased competition for limited transportation funding from states in the south and mid-west, is unlikely to have as favorable a net impact toward the Commonwealth. **These changes in the federal funding climate are occurring just as the project is about to undergo its heaviest construction period and cash flow requirements are about to peak.**

The likely result of the federal highway funding formula adjustment is that the state may have to pay a much larger proportion – possibly as much as 30% or 40% -- of the cost for the Artery/Tunnel than the 10% share anticipated when the project was initially funded.

1. Federal funds

The major unknown variable in the current funding plan -- one that is crucial to its share of the future costs of the CA/T project -- is what the state can expect from the new federal highway legislation.

For FFY 97, the last year of ISTEA, the state expects to receive about $650 million. It has posited high, middle or low federal funds scenarios for subsequent years ranging from over $800 million a year to $450 million from a new federal law.

The battle over the new federal formula is being waged between the donor states, those paying more in federal highway taxes annually than they receive back in highway aid, (i.e., Florida, Texas and

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31 While providing for increased Interstate Construction funding to reflect the costs of inflation in the 1980's, ISTEA legislation recognized that, except for the CA/T project, the Century Freeway project in Los Angeles, and a few others, the Interstate System was complete. The legislation provided that the states would receive instead what was in effect a block grant, based on a complex formula which would guarantee that states would not suffer a steep decline in their annual highway trust fund allocations while the legislation was in force through 1997. Because of this provision, Massachusetts officials were not overly concerned with the ISTEA provisions in the early 1990's. However, as the Appropriations Committee of the U.S. House of Representatives stated in its report to the full House on the U.S. Department of Transportation fiscal year 1997 appropriations bill, the Interstate Construction funds provided to the project in fiscal 1995. "are intended to be the final contributions for construction under the Interstate program. Accordingly, Massachusetts must accept the risks associated with potential cost overruns and possible reductions in future federal-aid apportionment levels."

other southern and mid-western states) and the donee states, (i.e., Massachusetts, New York and other northeast states). The battle is not expected to be resolved before the end of 1997 at the earliest.

Massachusetts has done very well under the current ISTEA, averaging $830 million a year in apportionment or 4.5% of the total annual apportionment of about $18 billion. What everyone receives, however, is based on how much the Congress appropriates, which usually is limited to close to 90% of the apportionment amount.

There are several bills now in the Congress, each with significant support. Step 21, a bill sponsored by Senator Warner of Virginia and supported by 23 others, could have the most severe impact on Massachusetts' federal highway allotment. It would produce an annual apportionment of $430 million, about 1.7% of the $ 22.5 to $25.5 billion national highway funding total. Step 21 would produce a double whammy effect, giving Massachusetts a smaller proportion of a bigger pie. Another bill, sponsored by Senator Baucus of Montana and 16 others, called Stars 2000, would be similarly as damaging to Massachusetts as Step 21.

The President's bill and a bill offered by Senator Moynihan of New York and 33 co-sponsors (ISTEAII) offer the most for Massachusetts. The former would provide an annual apportionment of $580 million, or 2.9% of a $20 billion total, while Moynihan's would provide a $656 million annual apportionment or 2.7% of a total apportionment of $24.3 billion. Again, it is pointed out that actual funds or obligations that would be available probably would be closer to 90% of the above figures.

The recently passed balanced budget agreement only allows about $22.5 billion a year. (This could reduce the state's apportionments particularly under Step 21 and ISTEAII). Should an even worse case outcome than Step 21 result, the state would be forced to dig deeply into its tool bag of solutions, among which could be increased funds from Mass Pike and possible shifting of highway funds from non-CA/T projects, a concern of communities distant from the project.

2. The 1997 State Transportation authorization

The state administration sought approval of a multi- billion dollar transportation bond bill to cover the funding needs of the Central Artery Project, other federally-assisted statewide improvements in the State Transportation Improvement Program (STIP), and non-federally-assisted statewide transportation projects statewide at least through the 1999 federal fiscal year (FFY 99) or September 30, 1999. The Legislature enacted the bill in to law in May 1997.

Enactment of the legislation essentially:

- Allows CA/T construction to move rapidly and on a timely basis.
- Helps keep the project on schedule to closure.
- Allows the State to capture construction cost savings of up to $250 from the relatively low current inflation rate.
- Responds to the FHWA's ultimatum to disapprove future advance construction.
- Makes it easier to cope with the expected cash flow or obligations deficit of 1998-2001.
- Provides some comfort to the credit agencies.

- Sends a positive message to the Congress in its development of a new federal highway formula.

3. The breakdown

The new law authorizes $3.0 billion for the CA/T project, of which $1.7 billion would be federal share and $1.3 billion would be state share. Included in the state's share is an increased contribution to the project from Mass Pike of $700 million. Some $100 million of the state's share is for CA/T project costs that are not reimbursable.

The federal share of $1.7 billion includes $900 million which the state will issue in the form of GANS or short-term grant anticipation notes.

While the amount of the bond bill authorization is only expected to service needs through FFY 99, this is the schedule period that is most sensitive, with major construction under way and major construction awards to be made.

4. Construction awards

Chapter 11 of the Acts of 1997 responds to the need to fund the host of CA/T construction contracts in 1997 and 1998. According to the 1996 Finance Plan, construction costs made up $4.8 billion or 87% of the project's overall to-go costs in 1996.

Some $908 million in construction awards were made in 1996. By the end of 1997, almost another billion dollars in awards is expected to have been made; another $750 million is to be awarded in 1998. Altogether, between $3.0 and $3.5 billion in construction will be under way from awards made in the latter two years.

Timely construction awards will keep the overall schedule moving (the major element in keeping the $10.4+ billion current project cost estimate from erupting). Failure to provide timely funds could cause delay in contract awards which could bring about a ripple effect which would extend the project schedule with its potential for increasing overall costs.

Award of the contracts at this time enables the state to capture the benefits of the currently low inflation rate of 2.75%. The $10.4 cost estimate is built on an inflation rate of 3.35%. This 60 basis point difference, together with the project's ability to go full bore on construction, represents up to $250 million in essentially lower construction costs which at best would hold down the overall project cost and at worst offset unexpected cost increases.

Although there are likely to be future funding needs subsequent to FFY '99, the light at the end of the tunnel should be shining at that time.

The law also helps the state to deal with the obligations flow deficit of over $1.0 billion dollars between 1998 and 2001. Between these years, costs are expected to exceed anticipated revenue from the federal government while after 2001 those revenues are expected to exceed costs. Short-term

borrowing is authorized in anticipation of the post FFY 99 federal funding and would bridge the deficit gap with the law also providing state back-up for the short-term notes.

The law could serve as a comfort to the credit agencies who dislike the intermittent project borrowing with its uncertainty.

Finally, the law responded to the ultimatum of the FHWA which had notified the state that no advance construction approvals would be made after April 1, 1997 unless third party agreements were finalized and legislative options identified in the financial feasibility report of November 1996 were pursued.

Advance construction establishes future eligibility for federal funds, if and when they become available. Because there is no obligation of federal funds at the time of advance construction approval by the FHWA, the state has to have funding commitments for the full cost of each contract. As a prerequisite to FHWA's concurrence to advance construction contracts, the state had to demonstrate that it had sufficient cash, binding contracts with third parties, (i.e. Mass Port and Mass Pike), and/or unencumbered legislative authority to cover total contract costs, exclusive of the amount of federal funds actually obligated.

5. Effect on state debt

The state currently has three constraints on the size of its debt load -- two are statutory, one is administrative.

The first statutory constraint relates outstanding direct debt or general obligation debt to a predetermined figure. The direct debt limit amount was established in 1990 at $6.8 billion to be increased 5% a year. Thus, in fiscal 1996, the direct debt limit was $8.7 billion. Outstanding direct debt at the close of FY 1996 was $8.1 billion. This restraint is not considered significant at this time because of the moving target.

The second statutory restraint limits annual debt service to no more than 10% of total budgeted expenditures. For FY 96, it was 5.4% and is projected to be 5.7% for FY 97. Thus, it also is not a meaningful restraint at this time.

The more meaningful restraint is the administrative policy that tries to limit the annual issuance of debt to no more than $900 million. **This has the effect of maintaining the annual debt load and debt service relatively level since it tries to relate new bond issuance to bond retirement.**

6. The state's credit

While some believe such a large authorization might affect the state's credit rating, thereby increasing its cost of bond issuance, others would argue that timing of the actual issuance is the more important element of the credit equation, and certainly of the impact on the state's overall finances.

The rating agencies are well aware of the state's current debt load and large future authorizations, yet continue to rate the state highly.

In rating the state's last general obligation issue in September 1996, Fitch and Standard and Poor's rated it A+ and called the state's outlook "positive" even while recognizing that considerable transportation funding would be needed; Moody's rating was A1.

Fitch said, "While the economy has firmed and fiscal soundness has been restored, debt is still high and likely to remain so as considerable transportation needs remain to be funded."

Moody's, in its fall 1996 report, said, "The Commonwealth's above average credit rating standing acknowledges its restoration and maintenance of fiscal control in the years since 1991 and an economy which generates high personal income and continues to expand. These credit strengths are tempered by a heavy debt load, uncertainties regarding future debt requirements..."

Standard and Poor's in September 1996 also called the state's long-term outlook positive. It said, "significant capital needs will be addressed through debt issuance, which is expected to keep debt levels high. Potential additional costs for the Third Harbor Tunnel/Central Artery project, as well as new funding for prisons and schools, could create additional expenditure and debt pressures. The Commonwealth.....may need to make difficult choices between capital needs if it wishes to maintain the already high overall debt burden at current levels and to remain within its self-imposed target of maintaining future annual debt issuance at $900 million."

The capital needs choices in 1997 may not be as difficult, however, since the only other bond authorization, besides the transportation bond authorization this year, is the $685 million for court house construction and reconstruction. However, choices in 1998 and thereafter would be difficult.

The credit agencies dislike uncertainty and surprises, and would be more comfortable with the State putting its project funding needs up front.

The plan behind the state bond authorization is sound and should keep the project moving on schedule. Care must be taken to manage the issue to insure minimal impact on the state's bond rating. The bond issue also permits construction to move ahead full speed, thus creating the opportunity to realize up to $250 million in lower construction costs by locking in current low interest rates.

7. Grant Anticipation Notes -- GANS

Chapter 11 authorized the state to issue nearly $1.2 billion in grant anticipation notes (GANS) during the 1998-2001 period when CA/T project costs are expected to exceed available funds.

Short term anticipatory borrowing is a financing technique that is widely-used by governments. For example, this technique is used in anticipation of long-term borrowing when the bond market is weak or when there is insufficient need at the time for the bond funds (BANS). It is also used when immediate cash needs exceed current tax or other revenue collections (TANS and RANS).

For the CA/T project, 1998-2001 is the peak construction period, during which costs will greatly exceed the more level flow of available funds. This situation will result in a cash or obligations flow deficit. Between 2001 and 2005, the opposite situation should prevail with available funds exceeding costs and producing a cash flow surplus. Thus, GANS would be used during the cash flow deficit period to be repaid from the funds of the cash surplus period.

The problem is how to structure the notes to be repaid by federal funds in a way that will make them most marketable. State officials have met with several investment banking firms on how to best structure them, especially on how to enhance the security of the notes beyond the future federal grants.

Chapter 11 authorizes the use of the state's full faith and credit to support $900 million in GANS. The remaining $300 million might be secured solely by the federal funds without any credit enhancement. However, these would be harder to market and probably more costly to the state. There are various other ways to enhance the security of the notes, however; these alternatives are under discussion and may be used.

The use of GANS in the amount sought by Massachusetts has not been done before, but New Jersey recently issued GANS of about $500 - $600 million.

8. Metropolitan Highway System legislation

The new Metropolitan Highway System law creates a highway system within the Route 128 perimeter which will be owned and managed by the Massachusetts Turnpike Authority (MTA), including the major elements of the CA/T program. It includes a number of important implications for the Central Artery/Tunnel project:

First, it provides a mechanism for generating additional toll revenues on an expanded set of highway facilities which will include the new Ted Williams Tunnel, the existing Sumner and Callahan Tunnels, and the Masspike extension. These revenues will be needed to help finance the construction, operation and maintenance of CA/T components and to help with the short term cash flow deficit. The law provides flexibility to the MTA in establishing a toll increase policy, a factor the bond rating agencies consider critical when it comes to supporting MTA bonds. While the revenue potential applies only to existing toll facilities at present, there may be future opportunities to expand the tolling or "charge for use" concept to other components of the system, with appropriate changes in legislation at the state and federal level. This could be a way to provide a more equitable distribution of the burden of toll revenue generation among all the geographic segments of the metropolitan region. At present, tolls are charged on facilities heavily used by North Shore and metro west communities, while communities in the North and South that are served by I-93 pay no tolls.

Second, it puts the MTA in a new and important position in the CA/T construction process now in full swing. As eventual "owner" of CA/T facilities, MTA is in a position to absorb some of the role of the program manager in the remaining stages of the construction process, if it can expand its staff capability. The current program manager, the B/PB joint venture, is budgeted just until the end of 2000. The remaining six years to complete all the CA/T work will require management supervision, which ideally could be handled by switching some B/PB and MHD personnel to the MTA payroll. If

this happened before 2000, some portion of the funds currently allocated to the Joint Venture might be cut back.

Third, MTA expands its long term role in highway transportation not only by being the generator of major toll revenues, but also by becoming actual "manager" of traffic flows and capacity on what will be the key links in the metropolitan highway system. New traffic management technology will become an important feature of the future. In addition, MTA will have the opportunity to play a major role in the economic development of the region through the development of air rights over its highway facilities. All this requires that MTA become a more important and responsive professional agency, shedding its image as a third rate patronage-filled organization on the margins of transportation policy. It will need to fit more closely into the political fabric of metropolitan Boston and the state than in the past, without jeopardizing its independence.

MTA's toll generating ability will be tested by its need, under the 1997 bond legislation, to come up with $700 million as its share of project costs; by a poor federal funding scenario that could occur; and by its need to provide annual operating funds when the MHS system is complete.

The plan for MTA to become the owner of major CA/T facilities is sound, and it is needed as a toll revenue generating mechanism. If MTA can become a solid professional transportation agency, the ability of the state to reduce project management and operational costs should be enhanced significantly.

Table 5.1 --CA/T FUNDING/FINANCIAL ISSUES

SUBJECT	FINDINGS	COST SAVING POTENTIAL
STATE BOND AUTHORIZATION	Care must be taken to manage the issue properly to insure minimal impact on the State's bond rating.	Up to $250 million in lower construction costs could be realized from its host of construction contracts that can be awarded.
METROPOLITAN HIGHWAY SYSTEM LEGISLATION	The plan for MTA to become the owner of major CA/T facilities is sound. Its toll generating ability will be tested	If MTA can become a solid professional transportation agency quickly, the ability of CA/T to reduce management costs should be enhanced.
ISTEA AND FEDERAL FUNDING		If Federal funding can be increased over the conservative assumptions in the state finance plan, it will help in keeping borrowing costs low.
USE OF GRANT ANTICIPATION NOTES (GANS)	The use of GANS to insure the bridging of the cash flow deficit period is appropriate.	GANS are less costly and more marketable with the support of the state's full faith and credit.

CHAPTER 6--THE BENEFITS AND BENEFICIARIES

While the attention of the public has been and will be focused in the near future on the construction of the Central Artery and the Third Harbor Tunnel, there has been little recent public attention paid to the implications of the system, once completed. However, it is timely to consider a number of issues the policy makers will have to face when the system is in operation, the benefits are in place, and the costs of its operation, including retiring the sizable debt generated by the construction, are evident.

When all the construction is completed, there are three main categories of public benefits[32] that will result:

1. An improved flow of traffic in the center of the metropolitan region.
2. New environmental amenities.
3. New economic development opportunities.

1. Improved traffic flow

First and foremost, virtually all the heavy volume of through traffic now moving into, out of and through downtown Boston and the adjacent waterfront areas in South Boston on or above the surface will be moving underground -- out of sight and out of mind. The elevated Central Artery as we know it today will disappear and downtown Boston, one of the region's (and arguably one of the nation's) vital and vibrant economic assets, will have a much better environment in which to function, grow and expand with less traffic-related pollution than today. Traffic noise will be reduced and air quality may improve somewhat. Also the ability to control traffic flow and improve the safety of the highways in regional centers will be greatly enhanced.

Second, and equally important, people -- business travelers, residents, students, tourists, visitors to the region and employees -- moving to and from Logan Airport will have much better and quicker access, particularly those located to the West and South of downtown who currently access the airport by adding to the congestion and pollution of downtown as they line up to use the Callahan Tunnel. The connection of the new Ted Williams Tunnel to the Masspike, the Southeast Expressway and the new Central Artery Tunnel will make this travel much more convenient than it is today. Since the airport is one of the most important facilities supporting the entire economy of the metropolitan region and Eastern New England, improved access will be a major benefit. About 88% of Logan

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[32] **Other Benefits** -- There are a number of other economic benefits which the CA/T project has produced, two of which are most apparent. First, local companies involved in the construction and engineering industry will have an unmatched period of contract work which will boost their ability to improve the financial performance and increase their power nationally and internationally. This is so because of the new design and construction techniques used on the CA/T project that will be sought after in subsequent urban highway construction projects. Second, the jobs created in the design and construction of the CA/T program will have made significant contributions to the metropolitan economy over almost two decades of operation.

travelers begin or end their trip in Boston, requiring a trip to or from the airport.[33]

2. New environmental amenities

There will be a number of new public facilities that will enhance the environment of the region, including new parks, open spaces in downtown and along the Charles River in Cambridge, and a park on Spectacle Island in Boston Harbor made possible by using soil excavated for the tunnels to cap the existing landfill on the island.

Modernized sewers built in connection with the CA/T project, along with capping the Spectacle Island landfill, will contribute significantly to efforts to clean up Boston Harbor -- a long term priority of the region for environmental improvement.

The utilities relocation program allows the major water, sewer, and telephone service providers in the downtown area to install new and modernized facilities, including a fiber optics system.

3. New economic development opportunities

In addition to the 27 acres of land which will be made available for improvements in the quality of the environment in downtown Boston when the artery structure is removed, a new piece of important land area, previously only marginally accessible, will be opened up for high quality future economic development. The seafront area on the northern fringe of South Boston, still mostly parking lots and old, often obsolete industrial buildings, will be opened up for new development as a result of the new interchange on the Ted Williams Tunnel - Masspike connector as well as the new transit way connection to South Station. This will help provide expansion space both for the burgeoning financial institutions of downtown Boston and for businesses connected to the airport. While planning for the reclaimed land in the Artery corridor has received most of the attention, it is this area (in what once housed seaport functions) that may offer the most important long term economic benefits.

Already the new Federal Court House and the new World Trade Center office/hotel complex are under construction and the site for the proposed convention center has been selected in the area. There remain a number of other sites, many under the ownership and control of Massport and others owned privately, that will receive the accessibility windfall.

In addition to the metropolitan region's general public, who will be able to take advantage of the specific facilities and the improved environment created by the CA/T project, there are two specific categories of beneficiaries who should benefit more than most.[34] These are, first, the specific users

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33 Peter Blute, Move Massachusetts 2000 Update, April 1997, Vol. 4. No. 4

34 Overall, mitigation practices that have emerged from the Project have raised the standards for large-scale urban construction in both the quality and quantity of Project-neighborhood interaction. An elaborate community-liaison network that focuses on advance notification and sanction has given even smaller community groups influence and leverage in day-to-day uction operations. In fact, the public dimension of the Project involves an impressive array of community based groups ranging from super coalitions like Mass Move 2000 to smaller groups representing distinct constituencies (like the Fort Point artists). Through the umbrella groups, scores of private and nonprofit organizations have become well-educated, sophisticated, thoroughly active

of the new highway facilities, and second, the owners and users of the property receiving the accessibility windfall. Both of these categories should be able to contribute a higher share of the operating costs of the system, including debt retirement, than the rest of the public.

The users of CA/T system improvements

With the completion of the expanded and depressed Central Artery and the links from the Southeast Expressway and the Turnpike extension to the Ted Williams Tunnel, there will be dramatic improvements for highway users (private autos, commercial vehicles like taxis and limousines, and trucks) making three specific types of trips;

- Those moving through the center of the region from North to and from the South on I-93 using the Artery. These trips represent about 70% of all traffic carried on the Artery at present.

- Those using I-90 and I-93 to reach downtown destinations, (about 30% of present Artery traffic).

- Those moving to and from Logan Airport and the North shore communities using the three tunnels and the Tobin Bridge now serving the area.

Of these three major beneficiaries of travel improvements, users of the tunnels and the Turnpike extension are the only ones who will be charged a toll for the use of the facilities. Those using I-93 will not be so charged, even though the Central Artery tunnel will be the major expense of the system. While the decision not to erect traffic bottleneck-producing toll barriers on I-93 was made early on in the design process,[35] there may be other technologies available in the future to charge users of the system elements and help balance out the current charge structure. We note that the issue of the imbalance of the burden of paying tolls to help finance the costs of the CA/T project were noted at the recent hearings on the Metropolitan Highway System legislation. While Boston region drivers pay relatively low tolls on their highway facilities compared to those paid by drivers in the New York region, for example, they should be able to afford the increases proposed as part of the MHS system operation. However, the question of who among the system beneficiaries should carry the burden of the costs of these expensive improvements is an issue which should continue to be placed on the public policy agenda.

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in the planning function, and generally able to work out difficulties. In the long term, then, the project may have served to unify diverse constituencies and even strengthen the political influence of groups in a city that has long been known for being unable to overcome divisiveness among community stakeholders.

[35] While Federal law provided that new highways built under the Interstate Highway Program were to be toll free, the provisions of the current Federal regulations can permit Federal Interstate funds to be used for constructing toll facilities, at the discretion of the States.

Land development beneficiaries

There are a number of specific beneficiaries who should be able to profit from the improved accessibility of the areas in which their property is located as a result of CA/T improvements. There are two which stand out above the rest. These are;

- **Property owners in the South Boston industrial waterfront**, which include both public agencies like Massport and a number of private interests. These owners are already developing plans for major new developments in the area under the general guidance of the Boston Redevelopment Authority, a situation which should transform the area into one of the outstanding waterfront commercial and residential areas in future years.

- **Property owners in downtown**, particularly those public agencies and private interests with parcels in the Government Center North end area which will benefit greatly from the removal of the Central Artery viaduct. Included in this mix are the major tourist attractions like Faneuil Hall Market Place and the New England Aquarium along with some hotels and other commercial establishments in the North End. These are the properties whose current users are suffering the most from the current construction activities, but whose owners should reap the greatest long term benefits.

Windfalls and wipeouts

To date, one of the least discussed features of the CA/T project is the fact that even though it is the most costly of the major urban highway construction projects undertaken in the United States, it is likely to be the one in which **the windfalls, particularly in the form of the increased value of affected property,** not to mention those accruing to businesses benefiting directly from improved highway services (taxi and limousine owners featuring Airport service, for example), **far outweigh the wipeouts resulting from property takings.** This is a unique feature of the program, due in large part to the ability of most of the improvements to be made within the boundaries of existing rights-of-way. The ability of the general public, whose agencies and tax resources are paying for this massive investment, to share in the windfalls should be an important item on the public policy agenda of the region.[36]

Examining longer term policy issues re: benefits/cost recovery

As the construction of the various pieces of the CA/T project are completed and put into operation, the important public policy issues will focus in large part on what measures the Commonwealth can take to recoup the costs of developing this tremendous but costly improvement in the infrastructure of Metropolitan Boston. While to date the public policy issues have correctly focused on how the project should be built and what should be included in the extensive package of improvements being implemented, the policy issues involved in how the benefits are distributed and how the beneficiaries

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[36] During the intense period of development of the Interstate system in the 1970's, the Federal Highway Administration undertook a number of research studies designed to determine the extent that the highway program was creating windfalls and wipeouts and how the windfalls could be used to compensate for the negative impact of the wipeouts.

might be asked to contribute to the cost have not received the same scrutiny. Among the range of urban public services, transportation system improvements in particular are among those most susceptible to user charges and do not require funding from general tax revenues.

However, there are controversies that can be expected in deciding on good user charge and cost recovery policy. Which of the various beneficiaries of the improvement should contribute to its continuing operation and upkeep of the improved system, including servicing its debt ? In what form should this contribution be collected -- through tolls, gas taxes, benefit assessments on affected property, special licences for major users, additional fees on downtown parking, and others? What is fair and what will fly? We think these questions are particularly appropriate for the Legislature to consider since significantly more of the cost of the project will fall on Commonwealth public resources than was anticipated when the project was conceived in the heyday of the federal government's Interstate Highway program.

As part of this study, the McCormack Institute was able to benefit from public opinion surveys which questioned Massachusetts citizens on their attitudes toward the "Big Dig." In one such survey dealing with attitudes towards broad public policy issues, of those who responded that they had heard something about the project, over 80% were able to identify benefits resulting from the project and over 70% responded favorably to the question of whether the state should try to come up with the money to complete the project if the federal government decided to spend less than its original share.[37] However, in another survey focusing on the performance on the Massachusetts agencies during the Weld administration, the response to the question of how the state should pay for the project, over 60% of the respondents were opposed to increases in tolls on any of the existing facilities, and higher percentages opposed raising gas taxes or using general revenues. Furthermore, among all the transportation and public works agencies whose performance was ranked for general satisfaction, the CA/T project management was ranked the lowest. This led the authors of the survey to conclude that "the combination of dissatisfaction with project management and lack of support for funding solutions suggests that the project could become a political nightmare ..... This is a project in need of more public explanation of the benefits and costs associated with it."[38]

There are a whole set of public policy issues involved in any attempt to determine what are fair and equitable methods for encouraging various categories of beneficiaries to contribute to the cost of the CA/T improvements. But there is also time before the facilities are opened to study the options and air the debate. Such an airing appears to have some urgency. As a prelude to any legislative action in this arena, additional research and analysis could provide data for these issues to be identified and discussed with various parties at interest. We think it would be in the interests of the Commonwealth to see that this research is carried out with dispassionate education of the public in mind.

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[37] From an analysis of the UMass/McCormack surveys of 400 Massachusetts voters conducted in January and April, 1997

[38] From Mass Insight; "State of the State; Year Seven of the Weld Administration" February, 1997 (Mass Insight surveys conducted by Opinion Dynamics Corporation), pages 14, 15, 19.

Appendix 1

Analysis of CA/T Project Cost: History and Trend

1. Introduction

This appendix includes a series of notes addressing several topics on the cost of the Central Artery/Tunnel (CA/T) Project. These include the historical cost growth, the structure of the project cost managed and reported by the CA/T Project Office, and the monitoring of the project cost to highlight trends.

2. Tracking Historical Cost Growth Data

Recent news reports cite two different figures for the cost: $7.78 billion in the Boston Globe[1,2] and 10.4 billion in both the Boston Globe[3] and Patriot Ledger[4]. At its inception in 1985, the CA/T Project had an estimated price of $2.564 billion. Subsequent scope and design changes led to an estimated cost at $7.78 billion[5]. Further revisions and additions to the project resulted in the cost of $10.4 billion[6] in 1996. The following paragraphs summarize the nature of these changes and revisions in order to clarify the contexts of the different cost data.

There are apparent differences between the cost data from Central Artery/Tunnel Project Office and those used by the GAO. McCormack Institute prepared a set of cost charts for the CA/T Cost Study[7] for comments by CA/T Project Office. We received comments annotated on a working document prepared by the McCormack study team, the F/C/R, by CA/T project management[8] on March 18, 1997; Attachment 1 in this response includes corrections to various cost figures.

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[1] Biers, John M, "Rep. Kennedy Denounces Weld Over Possible Big Dig Funds Loss," The Boston Globe, February 6, 1997.
[2] Palmer, Thomas, Jr., "State Could Get Help Financing Big Dig From Clinton, Moynihan," The Boston Globe, March 9, 1997, p B8.
[3] Palmer, Thomas C., Jr., and John M. Biers, "State Would Lose Less in Highway Bill," The Boston Globe, March 13, 1997, p A1.
[4] Layton, Lyndsey, "No Tolls for Expressway," The Patriot Ledger, February 12, 1997, p 6.
[5] "Finance Plan," Central Artery/Tunnel Project, Massachusetts Department of Highway, August 1995 as Amended February 1996.
[6] "Finance Plan," Central Artery/Tunnel Project, Massachusetts Department of Highway, September 1996.
[7] "CA/T Cost Study – Findings/Conclusions/Recommendations(F/C/R): Initial Story Line" Unpublished Working Draft, McCormack Institute, University of Massachusetts Boston, March 4, 1997.
[8] Edwards, Bill, "Joint Venture (CMS/ARL/WHE) Comments on the Working Draft," Attachment 1 to "McCormack Institute Request," Interoffice Memorandum to Ann Davis, Central Artery Project, Massachusetts Highway Department, March 13, 1997. This contains both answers to questions from the McCormack Institute in the said Request and comments to the Initial Story Line, March 4, 1997.

Table 2-1 Summary of CA/T Project Scope Changes

Year	Projectwide	C.A. North	C. Artery	C.A. South	South Bay	South Boston	East Boston
1985		Depressed C.A. emerges and crosses Charles River	Depressed and widened to 8 lanes		Seaport Access Tunnel (Fort Point Channel) crosses over MBTA Red Line	Seaport access tunnel, Surface street access.	Access to Logan Airport Access to Rte 1A 4-lane Third Harbor Tunnel
1987					South Boston Haul Road		
1989	1984 Regulations		C.A. "high profile" over Red Line	I-90 HOV Facilities	Mass Ave. Interchange Extension of I-93	I-90 HOV I-90 "tunnel cover" S. B. Bypass Road	I-90 HOV Toll Plaza. Rte 1A Interchange
1991		Scheme Z Add City Sq. tunnel connectors	Reconstruct Dewey Sq. Tunnel	Revised contract packaging			Tunnel Covers
1991	Fire Test Program	Remove City Square Connections	Green Line temporary ramp. Public transportation Infrastructure	Relocate Substation 3, Utilities relocation	BMIP tunnel South Boston Haul Road Temp. Operations Control Complex		Utilities relocation (e.g. Porter St.) Reinforcing steel design
1992	Public Trans. Infrastructure. Schedule extension to 2004	Anelex judgment, NBGC cost-to-cure, Temporary CANA ramps	Temporary Northern Ave. on-ramp		Expand OCC Relocate MHD District 8 and Materials Testing Facility		Remove E. Boston Interchange. Implement CLV Design Scheme
1992	Program Management (1998-2004)	Charles River Crossing, Leaverett Circle, Extend Project to Sullivan Sq.	Impacts from Charles River Crossing Improvements				

Source: Central Artery/Tunnel Project Office

2.1 Scope Changes: 1985 to 1992

A series of major scope changes occurred in the period from 1985 to 1992. These changes are summarized in Table 2-1. There are significant cost impacts[9] associated with these changes. Table 2-2 shows the cost increases that are allocated directly to the Central Artery Project.

Table 2-2 Scope Changes, $K

	Estimated Cost	
Item	GAO, 1995	CA/T March 1997
Original Estimates		
Charles River Crossing	508,000	508,000
I-90/I93 HOV Lanes	262,000	262,000
Right-of-ways	173,000	173,000
Extend I-93 South	130,000	130,000
Utility Relocation	85,000	85,000
South Boston Haul Road/Bypass Road	53,000	23,000
Deleted Rte 1A Interchange	(18,000)	(18,000)
Subtotal, CA/T highway	1,193,000	1,163,000
Tunnel Covers	176,000	176,000
Material Disposal/Hazardous Materials	141,000	141,000
Subtotal. Mitigation	317,000	317,000
Joint Venture Contract	263,000	263,000
Workmen's Compensation	237,000	237,000
Other	612,000	642,000
Subtotal,	1,112,000	1,142,000
Total 1993 Estimates	2,622,000	2,622,000
1995 Adjustments (Note 1)	**897,000**	**258,800**
Total Adjusted Changes	**3,519,000**	**2,880,800**

Table 2-2 shows the scope changes up and through 1995. The costs associated with these changes are based on comments from the CA/T Project Office and GAO report.[10] There are differences between the GAO and CA/T data in three items: (1) South Boston Haul Road/Bypass Road, (2) Other, and (3) 1995 Adjustments. The difference in costs is most pronounced for the item on "1995 Adjustments".

The item, "**Other**", has a substantial cost of **$612 M** (GAO estimate) or **$642 M.** Neither the GAO report nor the CA/T Attachment 1 explains the nature of this item.

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[9] "Joint Venture (CMS/ARL/WHE) Comments on the Working Draft," Attachment 1 to "McCormack Institute Request," Interoffice Memorandum to Ann Davis, Central Artery Project, Massachusetts Highway Department, March 13, 1997.

[10] Kenneth M. Mead, "History of Central Artery/Tunnel Project Costs," Enclosure III, in Letter to Frank Wolf, Chairman, Subcommittee on Transportation Committee on Appropriation, House of Representatives, GAO/RCED-95-213R, June 2, 1995, United States General Accounting Office, Washington, DC. All amounts are in 1994 dollars.

The item "1995" Adjustment, consists of, according to the GAO report (Enclosure V, p 17), provisions for further cost growth:

Design cost growth @18%	$352.0 M	
Construction cost growth @ 15%		$545.0 M
Total		$897.0 M.

The Joint Venture however identified this adjustment (Attachment 1)[11] as the Third Party related costs (see Section 2.2) at $258.8 M.

2.2 Support Costs (Exclusions) and Third-Party

Sometime during the period of 1985-1995, the CA/T Project assumed management responsibility for a number of other projects related to but not directly part of the core construction of the Artery and the Tunnel. These other projects fall into two categories: Support (or exclusions) and Third Party. The Exclusions are items not included as the direct cost of CA/T Project and are not eligible for (or excluded from) federal funding support. The cost for these project elements are referred to as Support Costs by CA/T Project. Table 2-3 tabulates these support items. Also included in Table 2-3 are the Third Party Costs for projects elements that are paid for by third parties but are integrated into the CA/T Project. These are primarily MBTA facilities and certain state-wide roadway projects.

Table 2-3 consists of two parts (A) and (B). Panel (B) shows the Exclusion items listed in CA/T Finance Plan[12]. Panel (A) lists the items included in the GAO report[13]. The costs in Panel (A) are those reported by GAO as well as those based on comments from CA/T.

It is noted that there is no one-to-one correspondence between the items in Panels (A) and (B). The total estimated by GAO is $12 million higher than the CA/T estimate. Finally it is noted that in Panel (B) there is one item referred to as Third party cost at $13 million.

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[11] "Joint Venture (CMS/ARL/WHE) Comments on the Working Draft," Attachment 1 to "McCormack Institute Request," Interoffice Memorandum to Ann Davis, Central Artery Project, Massachusetts Highway Department, March 13, 1997.

[12] "Finance Plan", Central Artery/Tunnel Project, Massachusetts Department of Highway, August 1995"as Amended February 1996, p 13.

[13] Exclusions are from Kenneth M. Mead "Summary of Items Excluded from MHD's Draft Estimate," Enclosure IV, in Letter to Frank Wolf, Chairman, Subcommittee on Transportation Committee on Appropriation, House of Representatives, GAO/RCED-95-213R, June 2, 1995, United States General Accounting Office, Washington, DC. All amounts are in 1994 dollars.

Table 2-3 Support Costs (Exclusions). $K

(A)			(B)	
Items	**GAO Estimates 1995**	**CA/T Estimates Mar 1997**	**Items**	**CA/T 8/95, Amended 2/96**
	[1]	[2]		[3]
Connections to Turnpike Facilities	248,900	230,000	Project/Toll Interfaces	230,000
Logan Airport (Connections to Rte 1A)	177,000	180,000	Logan Airport Interchange	180,000
Maintenance/Support Facilities	52,700	55,000	Operation/Maintenance	55,000
Tunnel Fire Testing (in W. Virginia, for CA/T Tunnels)	44,600	45,000	Research and Development Agreements	45,000
Temporary Facilities (I-93 ramps, message signs etc.)	19,100	19,000		
Scope Deferrals (HOV)	18,100	18,000		
Highway Cost	560,400	547,000	Highway Cost	510,000
Transit Related	68,600	67,000	Transit Related Scope	67,000
North-South Rail Link	6,300	6,000		
State-only Funded Items	169,500	170,000	State Transportation Improvements	170,000
Other Transportation-related Cost	244,400	243,000	Other Transportation-related Cost	237,000
Surface Restoration (CA, Ft Point Ch, Spectacle I.)	69,400	50,000	Artery Restoration Enhancements	50,000
Environmental Mitigation (Cambridge; CB training; Fire Departments, etc)	105,700	105,000	Environmental Mitigation Agreements	30,000
			Mitigation/Interagency Service	75,000
Mitigation Cost	175.,100	155,000	Mitigation Cost	155,000
Others	29,900	53,000	Other(Broadway, Summer St bridges, surface streets.)	82,000
			Third Party Cost (MBTA)	13,000
Others, subtotal	29,000	53,000		95,000
Total	1,009,800	998,000	Total	997,000

2.3 Inflation

In addition to the effects of scope changes and exclusions, the CA/T Project cost has been escalating due to inflation. The cost increases over the years due to inflation are summarized in Table 2-4.

The data on inflation are drawn from three sources. There appears to be significant divergence in the estimated inflation for the period from 1994 through 2004. The CA/T estimate of $1387 million is nearly 100% higher than the GAO estimate of $737 million.

Table 2-4 Cost Impact from Inflation, $ M

	Inflation SM		Notes
1985	-		
1987	565		1
1989	462		1
1991	458		1
1992	641		1
1993	428		1
Subtotal	2554		
	GAO	CA/T	
1994-2004	737	1387	2,3
Total	3291	3941	

- Note 1: Inflation data from Luberoff and Altshuler.[14]
- Note 2: Inflation estimates, GAO report (Enclosure V).[15]
- Note 3: Inflation estimates, CA/T (Attachment 1)[16]

2.3 1995/1996 Cost Estimates

The preceding account of the elements of cost growths are summarized in Table 2-5 indicating the resultant cost estimates of $7.74 billion in the 1995 Finance Plan and of $10.4 billion in the 1996 Finance Plan.

Table 2-4 shows the cost growth on the CA/T Project from 1985 to 1996 based on the changes described above both in accordance with the GAO estimates and the CA/T estimates. The final 1995 and 1996 estimates from the two organizations are identical although there are large differences in the estimated scope adjustments in 1995 and the expected out-year inflation. Table 2-6 shows the historical cost growth trend using the scope change data from Luberoff and Altshuler (1996). In this table, we use the 1995 GAO estimates for the adjustments and future inflation allowance. The result, as noted above, would be unchanged for the total estimated cost in 1995. Figure 1 shows the cost growth graphically.

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[14] Luberoff, David, and Alan Altshuler, "Mega-Project: A Political History of Boston's Multibillion-Dollar Artery/Tunnel Project." J. F. Kennedy School of Government, Harvard University. Revised Edition, April 1996.

[15] Kenneth M. Mead, "History of Central Artery/Tunnel Project Costs," Enclosure III, in Letter to Frank Wolf, Chairman, Subcommittee on Transportation Committee on Appropriation, House of Representatives, GAO/RCED-95-213R, June 2, 1995, United States General Accounting Office, Washington, DC. All amounts are in 1994 dollars.

[16] "Joint Venture (CMS/ARL/WHE) Comments on the Working Draft," Attachment 1 to "McCormack Institute Request," Interoffice Memorandum to Ann Davis, Central Artery Project, Massachusetts Highway Department, March 13, 1997.

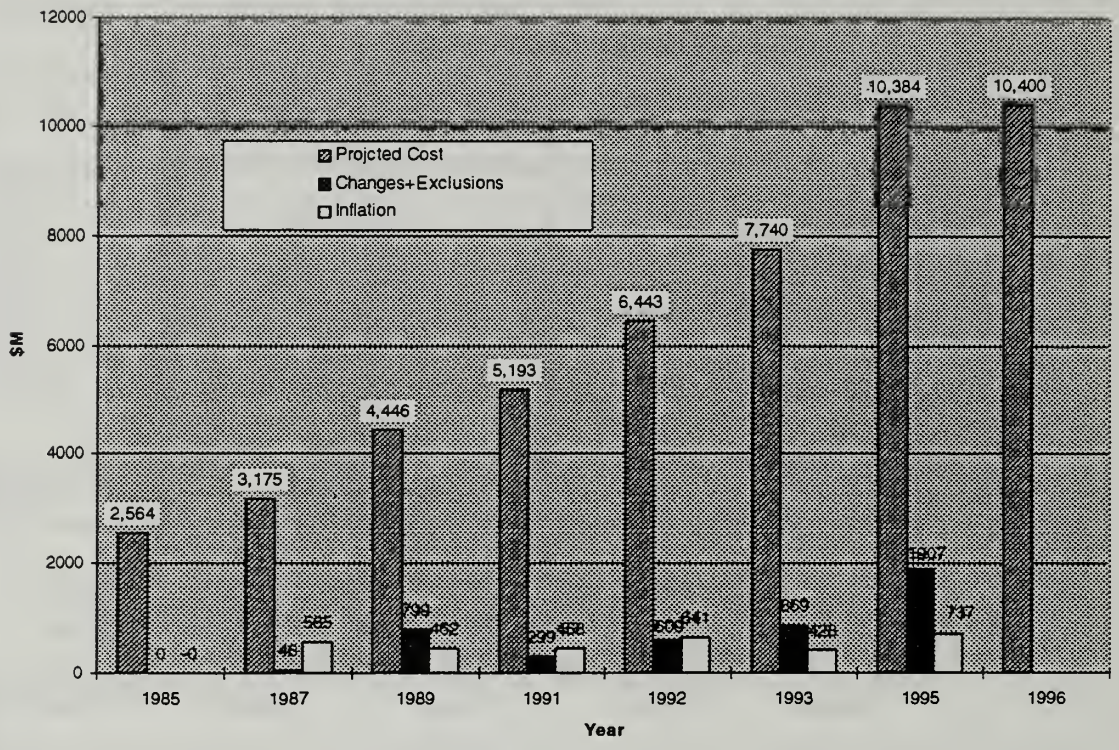
Table 2-5 Budget Estimates, $M

	GAO	CA/T
1985 Estimate	2,564	2,564
Inflation through 1993	2,554	2,554
Scope Change Pre-95	2,622	2,622
1995 Estimate, Unadjusted	7,740	7,740
Exclusions	1,010	998
Scope, 1995	897	259
Inflation 1993-1995	737	1,387
1995 Estimate	10,384	10,384
1996 Finance Plan	10,400	10,400

Table 2-6 History of Project Cost Estimate

Year	Estimate	Exclusions	Changes	Inflation	Projected Cost
1985	2,564.0	-	-	-	2,564.0
1987	3,185.0		46.0	565.0	3,175.0
1989	4,436.0		799.0	462.0	4,446.0
1991	5,193.0		299.0	458.0	5,193.0
1992	6,443.0		609.0	641.0	6,443.0
1993	7,740.0		869.0	428.0	7,740.0
1995	7,740.0	1,009.8	897.0	737.0	10,383.8
1996	10,400.0				10,400.0
Total		1,009.8	3,519.0	3,291.0	

Figure 1 Growth of Project Cost



2.4 Finance Plan Budgets

The Finance Plan (August 1995 as amended February 1996) lists the CA/T budget being $7.78 billion in1995 and $10.4 billion in 1996. The Finance Plan, September 1996, reaffirms the budget at $10.4 billion. Table 2-7 summarizes the budgets by functions.

Table 2-7 Summary of Financial Plans, $ B

	Finance Plan 8/95 amended 2/96		Finance Plan 9/96		
	[1]	[2]			[3]
Type	C/SU R6 Estimate (Updated)	Total (2/ 96)	Cost to Date (7/1/96)	Remaining (7/1/96)	Total (7/1/96)
Construction	5.871	7.1	2.4	4.7	7.2
Design	0.770	0.9	0.8	0.2	1.0
Right of Way	0.386	0.4	0.4	0.0	0.4
Sale of Air Rights	-0.225				
Prior to ICE and Committed Escalation	-0.391				
Program Management	1.369	2.0	1.3	0.5	1.8
Total	7.780	10.4	4.9	5.4	10.4

Table 2-7 shows that the total budget and need-as-of date are:

	Budget, $B	Need as of	Source
[1]	**7.78**	**7/1/95**	**Finance Plan, 8/95 Amended 2/96, Table 1**
[2]	**10.4**	**7/1/95**	**Finance Plan, 9/96, p.vii**
[3]	**10.4**	**7/1/96**	**Finance Plan, 9/96, p vii**

There is a discrepancy of $40M between the budgets of $7.74 B and $7.78 B in Table 2-5 and Table 2-7 respectively for the unadjusted 1995 estimates. This may be in part due to the 'saving' of $225 million from air rights in column [1] whereas elsewhere in the Finance Plan, the air rights are 'saving' from air rights.

> The saving from air rights is also referred to as credit for future sale of air rights. Whichever the name , the item amounts to a reduction of project cost when it is credited to the project account. Section 3.1 provides a discussion on the inclusion of this item in the budget.

There is a large increase in estimated management cost from $1.369 billion in February 1995 to $1.805 billion in September 1996. There is no explanation in the Finance Plan for the large increase in the management cost. Factors that possibly contribute to this increase include: Insurance, Management cost for the Exclusions and scope changes, and reserves.

We considers the September 1996 Finance Plan Estimate, Column [3], as the latest official baseline; this is also widely cited by various government officials and news media. The operating budget in the CA/T monthly management report differs from that in the Finance Plan budget. Even for the month of June 1996, the base month for the Finance Plan, the budgets are $10.92 B (excluding air rights) and $10.4 B respectively.

3. Cost Structure and Monthly Management Report

3.1 Project Cost Summary

The Central Artery/Tunnel Project Office holds monthly meetings for management review. The Monthly Management Report is therefore the most useful method to for tracking progress on the project and related changes. The CA/T Project office manages the project cost in three parts: CA/T Direct Costs, Support Costs, and Third Party Related Costs. However, the monthly management report includes only two cost charts:

> CA/T Direct Costs and
> Support Costs (Includes Third Party Related Costs).

These charts, Panels (A) and (B), from the monthly report for January 1997 (pp. 17A and 17B) are shown in Table 3-1. Oddly, the report does not include a top level summary chart for the total project under management. Table 3-1 includes this missing chart, Panel (C), for the total cost, i.e., the sum of the direct and the support costs.

Air Rights

The cost elements in these charts include a credit for air rights. CA/T Project Office regards this as a potential cost saving and treats it as a cost item in the budget. The consequence of this treatment is a reduced project cost. The McCormack Institute regards the recovery of the air rights as a source of revenue that, when recovered at a future date, would partially pay for the cost of the project. It is not a cost saving on the project. The CA/T Project results in a future physical asset owned by the Massachusetts Highway System; the value of the asset value includes marketable value of the air rights. There is a difference between these two views: (1) the cost to acquire an asset, the project cost and (2) the future book value after a part of the asset is disposed of. Consistent with view (1), the total costs in these panels in Table 3-1 are adjusted to exclude the air rights. (CA/T Project Office acknowledges this alternate method of accounting in its September 1996 Finance Plan by excluding the air rights in its budget estimate of $10.4 billion.)

Current Budget: Unescalated vs. Escalated

CA/T management report shows both unescalated and escalated current budgets. The escalated current budget is the more meaningful of the two because it represents the expected cost as it is incurred and paid for in nominal money. In the discussion to follow, the current budget, escalated, is used unless stated otherwise. However, before we leave the subject of unescalated budget, we note that the total direct cost budget (unescalated) is $7998M in Panel (A) whereas Finance Plan budget estimate is $7780M.[17] The difference between these two budget numbers is a sizeable $218 M. The escalation of the total project cost, Panel (C), is $1.233 B (=10.991-9.758) also does not appear to relate to the estimated inflation in Table 2-5. Thus the origin of the budget plan in Table 3-1 remains a question.

[17] "Finance Plan," Central Artery/Tunnel Project, Massachusetts Department of Highway, August 1995 as Amended February 1996, Table 1, p 12.

Table 3-1 Central Artery/Tunnel Project Cost Summaries– As of January 31, 1997

	(A) Jan-97 Direct Costs, $M				(B) Jan-97 Support Costs, $M				(C) Jan-97 Direct + Support Cost, $M			
	Current Budget (Unescalated)	Current Budget (Escalated)	Potential Forecast	Cost-to-date	Current Budget (Unescalated)	Current Budget (Escalated)	Potential Forecast	Cost-to-date	Current Budget (Unescalated)	Current Budget (Escalated)	Potential Forecast	Cost-to-date
Direct Construction												
Construction Packages	5369	6215	6518	3811	911	1042	939	262	6280	7257	7457	4073
Force Account-Construction	302	322	334	221	39	41	40	29	341	363	374	250
Geotech Contracts	18	18	19	19	4	4	3	3	22	22	22	22
Right of Way	302	302	338	256	114	114	136	116	416	416	474	372
Recovery for Air Rights	-255	-255	-255	0	0	0	0	0	-255	-255	-255	0
Subtotal	5736	6602	6954	4307	1068	1201	1118	410	6804	7803	8072	4717
Other Project Costs												
Force Account- Design	60	62	69	42	96	114	80	35	156	176	149	77
Section Design Contracts	657	721	737	659	128	131	122	100	785	852	859	759
Joint Venture	1340	1496	1496	902	135	136	136	92	1475	1632	1632	994
Insurance	99	148	-1	389	0	0	0	0	99	148	-1	389
Management Reserve	106	17	0	0	78	108	0	0	184	125	0	0
Subtotal	2262	2444	2301	1992	437	489	338	227	2699	2933	2639	2219
Project Total	7998	9046	9255	6299	1505	1690	1456	637	9503	10736	10711	6936
Non-recovery of Air Rights	255	255	255	0	0	0	0	0	255	255	255	0
Adjusted Total	8253	9301	9510	6299	1505	1690	1456	637	9758	10991	10966	6936

3.2 Design and Construction

The monthly report includes a series of gantt charts. The charts list time lines and cost data for work packages on design and construction. These charts, (pp. 3-13), tabulate the package costs by final design and construction for the segments of the project. One chart (January 1997 report, p. 2) provides summary data on the project activities. Table 3-2 shows these summary data. These summary data are also in agreement with the subsidiary package cost data in the gantt charts.

Table 3-2 Design and Construction Costs
(January 1997)

WBS	Current Budget (Escalated)	Potential Forecast	Cost-to-date
Final Design			
Tunnel	94.1	94.1	88.3
I-90	188.2	192.7	182.9
I-93	335.9	342.6	308.7
Systemwide	58.3	57.3	53.5
Design reserve	11.7	7.6	0
Subtotal Final Design	688.2	694.3	633.4
Construction			
Tunnel	1115.3	1126.3	1104.5
I-90	1702.1	1738.5	790.2
I-93	3819.4	3964.3	1956.6
Systemwide	592.2	600.9	213.5
Misc.	27.9	27.8	7.6
Subtotal Construction	7256.9	7457.8	4072.4
Total	7945.1	8152.1	4705.8

The subtotal for construction cost in Table 3-2 are in agreement with the costs for construction packages in Table 3-1, Panel (C). Because of this agreement for the construction packages, one would also expect similar agreement for the total cost of the final design packages. The design costs in Table 3-2 are different from and lower than the cost data in Table 3-1, in Panel (C) for the total project cost. Table 3-3 displays these discrepancies.

Table 3-3 Differences between Design Costs in January 1996 Report

Final Design	Budget	Forecast	Cost-to-Date
Project Summary Table 3-1	852	859	759
Design & Construction Table 3-2	688	694	633
Unidentified Design Items	164	165	126

3.3 Project Reserves

The cost data in the CA/T monthly report include various reserves. These are summarized in Table 3-4 from the January 1997 report. Reserves are held in accounts for design, construction, and management. The construction reserves are also known as project change authorization (PCA). Total reserve at end of January 1997 has a budget of $390 million and a forecast of $251.7 million.

Table 3-4 Summary of Project Reserve (January 1997)

	Current Budget	Potential Forecast
Design reserve	11.7	7.6
Construction (PCA)		
Tunnel	74	71.2
I-90	151.1	145.3
I-93	28.8	27.6
Subtotal Construction	253.9	244.1
Management Reserve	124.4	0
Total	390.0	251.7

3.4 Joint Venture Management Cost

The Joint Venture is currently operating under contracts for Work Plans 13 and 14. The monthly management includes separate management review charts (pp. 28A and 28B) for these two plans. Table 3-5 below shows the combined status of these two charts for month of January 1997.

Table 3-5 Management Cost, WP 13 and WP 14, $M

	Contract Max	Forecast	Current Budget	Expenditure
Direct Labor	170.3	170.3	30.7	28.7
Indirect Labor	189.5	189.5	34.0	30.0
Base Fee	36.0	36.0	6.6	6.6
Budgeted Incentive Fee	3.6	3.6	0.0	0.0
Total Labor Related	399.4	399.4	71.3	65.3
Direct Expense	91.9	91.9	22.2	16.5
Director's Reserve	1.8	1.8	1.8	
Total Direct Expense	93.7	93.7	24.0	16.5
Total Before Reserve	491.3	491.3	95.3	81.7
Reserve for Cost Basis Adj.	19.1	19.1		
Total	510.4	510.4	95.3	81.7

The management cost charts (pp. 28A and 28B) provide information only for a segment of the overall management cost. They do not directly relate to the project cost summary charts in Table 3-1 because the management report does not show explicitly either the pre-WP 13/14 cost or the post-WP 13/14 cost. The contract expiration dates are June 1997 for Work Plan 13 and December 1999 for Work Plan 14. We assume that both work plans, 13 and 14, started on or about 7/1/96 and that the cost prior to 7/1/96 were covered by Work Plans through No. 12. Since the contracts for work plan 14 expires in 1999, there will be a future work plan for management beyond 1999 until the completion of the CA/T Project in 2004. With these assumptions, one can infer from Table 3-1 and Table 3-5 that the future cost as shown in Table 3-6. This table indicates that beyond the contracts for work plans 13 and 14, there is a future work plan cost of $210 million required to complete the CA/T Project. Thus, the sum total of cost for work plan 13/14 and future work plans is $720 million, as shown in the last row of Table 3-6. This sum represents the to-go cost as of July 1, 1996. This compares with the to-go estimate of $505 million in the Finance Plan (September 1996). Thus, with the Finance Plan as a baseline, the current monthly report (January 1997) projects a cost growth of $215 million for the Joint Venture management.

Table 3-6 Reconciliation of Management Cost, $M

	Budget	Cost-to-Date	Estimate-to-Complete
Prior Work Plans, prior to 7/1/96	912	912	0
Work Plan 13			
Work Plans 14 (from Table 3-5)	510	82	409.
Future Work Plan(s)	210	0	210
Project Management Total (from Table 3-1)	1632	994	638
Work Plans, 7/1/96 to Completion	720	82	638

3.5 Budgets and Cost Variances

The Project currently uses a different breakout of the cost items from that in the Finance Plan which uses only four line items. This makes it difficult to analyze variance of any specific cost items. As an illustration, we consolidate the line items in the January 1997 management report to correspond to the items in the Finance Plan as shown in Table 3-7.

Table 3-7 Budgets and Cost Variances, $B

	7/96 Budget	Potential Forecast	Variance Forecast - Budget	
Type	Finance Plan, Sep 1996	Mgmt Report Jan 97	$ B	% of 7/97 Budget
Construction	7.20	7.85	0.65	9.1%
Design	1.00	1.01	0.01	0.8%
Right of Way	0.40	0.47	0.07	18.5%
Management	1.80	1.63	-0.17	-9.4%
Total	10.40	10.97	0.57	5.4%

In this consolidation,

- ◊ Two construction items and the geotech item in Table 3-1 are combined;
- ◊ Two design items are summed together; and
- ◊ Joint Venture and insurance items are lumped into one item.

Table 3-7 compares the consolidated forecast from the management report with the budgets for the comparable items from the 1996 Finance Plan. The variances between the forecast and budgets are shown in the left columns, in dollars and in percents.

The comparison indicates that the bulk of the cost increase is due to construction, at $650M, and the management cost has a projected reduction at $170M.

- Overall project cost increase is $0.57 B, at 5.4% of budget.
- In percentage, right-of-way incurs the largest increase at 18.5%.
- Management (including insurance and reserve) has the most favorable change at -9.4%.

The negative variance for management is most likely a consequence of including insurance and reserve in management at one time but excluding them at another. We examine this later.

It appears that the management line items in Table 3-7 have different compositions in the various budgets and forecast because of the different way insurance and management reserves are accounted for. Thus an appropriate way to evaluate cost variance is not to consolidate but to

disaggregate the line items to be consistent with the break out in the Management Report. We believe that the decomposition in Table 3-8 accomplishes this equalization.

Table 3-8 Decomposing Budget and Cost Variances, $B

	7/96 Budget	Potential Forecast	Variance Forecast- 7/96 Budget	
	[a]	[b]	[c]=[b]-[a]	[d]
Type	Finance Plan, Sep 1996	Mgmt Report Jan 97	$b	% 7/96 Budget
Construction	7.200	7.853	0.653	9.1%
Design	1.000	1.008	0.008	0.8%
Right of Way	0.400	0.474	0.074	18.5%
Management & Other	1.800	1.631	-0.169	-9.4%
Insurance	0.389	-0.001	-0.390	-100.3%
Reserve	0.125	0.000	-0.125	-100.0%
Management	**1.286**	**1.632**	**0.346**	**26.9%**
Total	10.400	10.966	0.566	5.4%

- Table 3-8 treats insurance and reserve as separate line items by making two assumptions.
- Assumption (1): Commitment on insurance, $389 M, in Table 3-1, was expenditure incurred prior to Work Plans 13/14.
- Assumption (2): The September 1996 Finance Plan estimate for the management cost indeed has $125 M tucked in Management as reserve.
- Given these assumptions, the actual management cost in the Finance Plan is as shown in Table 3-8, in amount of $1.286 billion.
- By restating the budgets with separate sub items as in Table 3-8, one sees a dramatic difference in the cost variance on the management items.
- Whereas the variance for management is negative at $169M when it is inclusive, the variance becomes positive at $346M when it is exclusive.
- The variance as percentage has a swing of 26.3%, from –9.4 to +26.9%, when the reserve and insurance cost are removed from the management line item.

4. Analysis of CA/T Contract Bid Prices and Contractors

4.1 Introduction

McCormack Institute received from CA/T Project Office a 71-item listing of the contract bid prices along with the pre-bid estimated costs. There were wide differences between the highest and the lowest bid prices for most contracts. Furthermore, there have been differences between the estimated cost and the actual bids.

4.2 Data on Bids

The data on bids cover 71 contracts in period from 1990 through January 1997 and are displayed in Table 4-1. The values of awarded contracts, to the low bidders, varied from under $500K to about $400,000K. There are significant differences between the bids and the estimates. For the individual contracts, the ratio of high bid to low bid varies from 1.00 to 3.00.
The following paragraphs present the results of analyzing the bid data.

4.3 Summary Statistics

The low and high bids, relative to the estimates, are both essentially normally distributed. The normalized low and high have mean values of 0.84 and 1.16 respectively. That is to say, on the average, the low bid is 16% below and the high bid is 16% above the cost estimate. Since the contracts are awarded to low bidders, one infers that any contract would have a value that is statistically at 16% below the estimate.

The mean difference between the low bid price and the estimated price show variation according to work breakdown (or project segment), Table 4-1, and according to year of contract award, Table 4-2. In these tables, the column "Sum" shows the total difference between the bid values and the estimated values of the contracts according to the classification.

Table 4-1 Difference between Low Bid and Estimate by WBS, $K

WBS	Sum	Average
S. Boston	(23,876)	(2,171)
E. Boston	(93,514)	(8,501)
South Bay	(118,139)	(11,814)
C. Artery	(67,088)	(4,473)
C. A. North	2,055	294
Projectwide	(77,970)	(7,797)
Geotech	50	17
General	(8,572)	(2,143)
Total	(387,055)	(5,451)

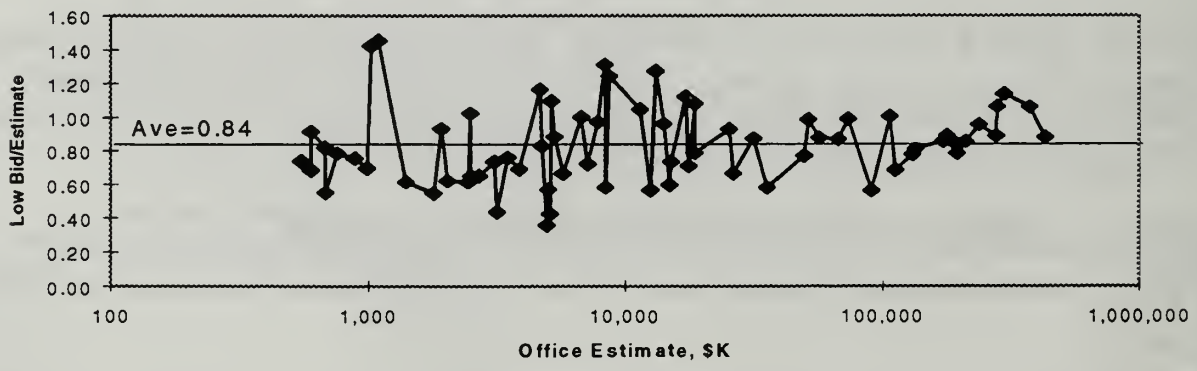
Table 4-2 Difference between Low Bid and Estimate by Year of Award, $K

Year	Sum	Average
1990	(578)	(289)
1991	(34,353)	(4,294)
1992	(83,636)	(10,455)
1993	(72,863)	(6,072)
1994	(67,264)	(5,174)
1995	(104,122)	(8,009)
1996	(64,300)	(4,946)
1997	40,061	20,030
Total	(387,055)	(5,451)

4.4 Distribution of High and Low Bids

The graph in Figure 2 shows the ratios high/estimate and low/estimate as functions of estimate. Visually there appears to be no relationship between the deviation bids from estimate that can be attributed to the magnitude of the estimate. This observation is corroborated by the results of regression analysis. The magnitude of estimate explains neither the high bid nor the low bid at 5% level of significance.

Figure 2 Ratios of High and Low Bids Relative to Estimate, $K



One should be cautious in interpreting the meaning of the data on the bids, particularly in attempting to predict future outcome. Section 5 examines the trends in the project.costs including the construction cost since January 1997.

5. Monitoring CA/T Cost Forecast and Variances

5.1. Introduction

The CA/T monthly management report is an essential tool for monitoring the performance of the Project. Each report provides a snapshot of the status of the project in time. This section of describes a methodology of using the reports for continuous monitoring of the project cost.

5.2 Methodology

Project Cost Summary

The financial data in the monthly reports provide the trends of the various project cost elements. To track the history of budget changes and forecast, we have recorded the summary cost data from the management reports. This provides a convenient way of examining and comparing the individual panels (Table 3-1) in a single spreadsheet. Also included on this sheet are the summary data on design and construction costs for the four major cost components (i.e., tunnel, I-90, I-93, and system-wide) of the CA/T Project. These costs are then summarized in Table 5-1 for those months for which we had the monthly reports. In Table 5-1, the project direct cost excludes air rights and the project support cost includes Third Party Costs.

Table 5-1 Monthly Summary Costs

	Direct Costs, $M				Support Costs, $M				Direct + Support Cost, $M			
	Current Budget (Unescalated)	Current Budget (Escalated)	Potential Farecast	Cost-to-date	Current Budget (Unescalated)	Current Budget (Escalated)	Patential Farecast	Cast-ta-date	Current Budget (Unescalated)	Current Budget (Escalated)	Potential Farecast	Cast-to-date
	Direct Cost				Suppart Cost				Direct + Support			
Mar-96	8253	9301	9146	3332	1426	1607	1527	386	9679	10908	10673	3718
Apr-96	8253	9302	9205	4951	1424	1605	1516	402	9677	10907	10721	5353
Jun-96	8254	9300	9384	5081	1437	1621	1495	406	9691	10921	10879	5487
Sep-96	8254	9301	9441	5193	1451	1637	1461	587	9705	10938	10902	5780
Jan-97	8253	9301	9510	6299	1505	1690	1456	637	9758	10991	10966	6936
Feb-97	8318	9377	9716	6655	1445	1619	1384	639	9763	10996	11100	7294
Mar-97	8318	9619	9788	7022	1247	1384	1324	675	9565	11003	11112	7697

One makes the following observations from the one-year data in Table 5-1.

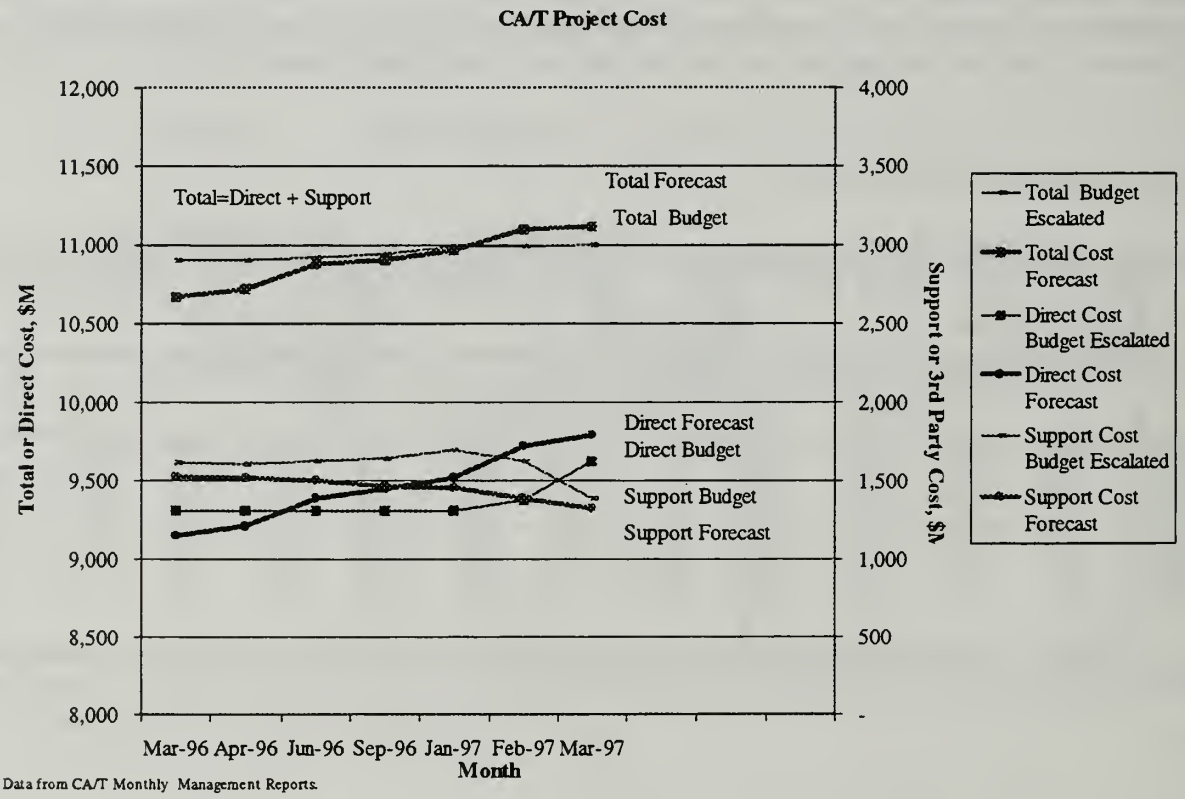
(a) The budget cost of $10.4 billion,[18] the "nominal cost", which was used in the Finance Plan of September 1996, is not in the table. The September 1996 Finance Plan forecast "to-go" cost at $5.5 billion as a mid-range scenario, the high being $6.0 billion.[19] Since the cost-to-date was $4.9 billion,[20] the total project cost (escalated) was implicitly $10.4 billion, the mid-range estimate, or $10.9 billion, the high-end estimate. The CA/T Project Office apparently uses the high-end estimate as the escalated budget in its monthly management report.

(b) The upward trend of the "Current Budget, Unescalated" for the Direct Cost since September 1996 is not explained. There has not been any known change in the scope of the project over this one-year period. Since the issuance of the September 1996 Finance Plan, the inflation rate has been fairly stable. Thus, there is no apparent cause for the change in the budget.

(c) Also unexplained is the trend towards lower Support Cost budget and the dramatically decreasing forecast for the Support Cost.

Figure 3 displays graphically these cost trends in Table 5-1 for the direct cost, support cost, and total cost, both the budgets and forecast, by month. There has been a clear rise in the Direct Cost The decline in Support Cost is also very evident. This decline partly negates the unfavorable trend in the Direct Cost.

Figure 3



Data from CA/T Monthly Management Reports.

[18] Finance Plan, Central Artery/Tunnel Project, Massachusetts Highway Department, September 1996, p vii.
[19] Ibid., p iv.
[20] Ibid., p vii.

5.3 Design and Construction: Forecast and Variance

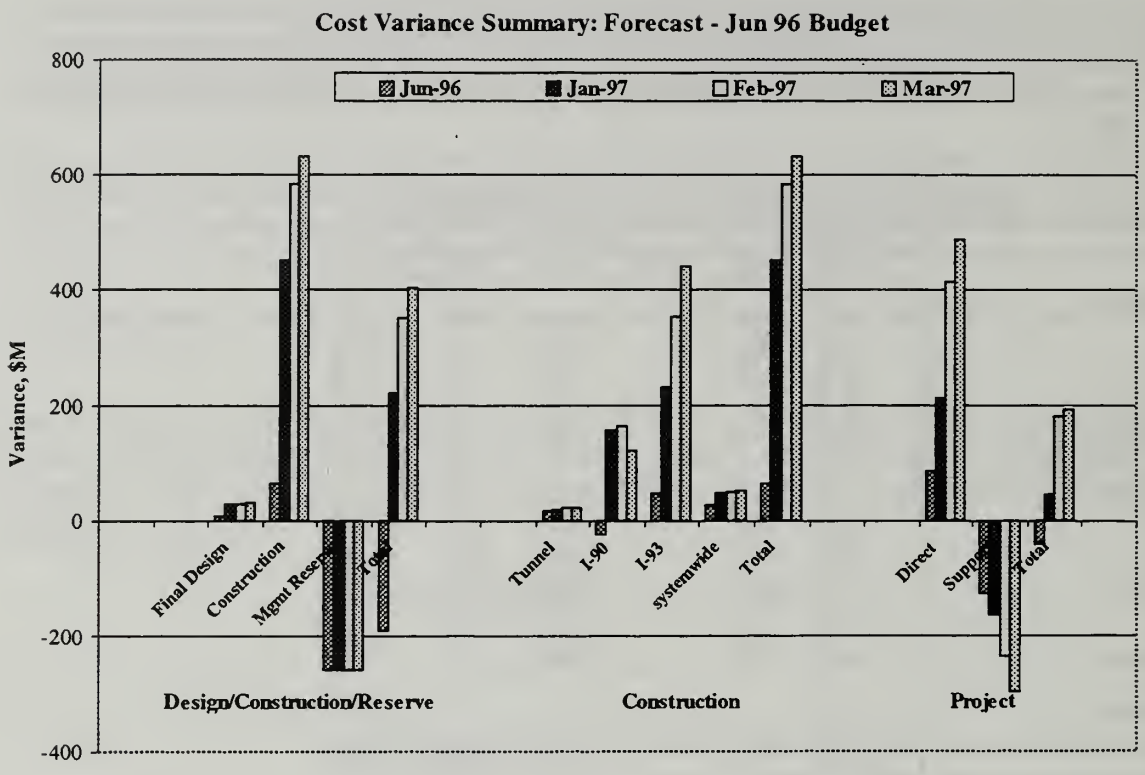
Table 5-2 summarizes the design and construction forecast for those months where data are available: June 1996, January through March 1997. The table includes also budgets for the month June 1996, the base month. One notes the rapid increase in the construction costs since June 1996.

Table 5-2 Monthly Forecast of Design and Construction Costs

	Budget	Forecast				
	Jun-96	Jun-96	Sep-96	Jan-97	Feb-97	Mar-97
Final Design						
Tunnel	94.1	94.7		94.1	94.1	94.4
I-90	184.5	186.9		192.7	193.5	192.5
I-93	318.2	325		342.6	340.9	341.9
systemwide	56.3	57.2		57.3	57.3	57.3
Design reserve	13.1	8		7.6	**7.3**	10
Final Design	666.2	671.8		694.3	693.1	696.1
Construction						
Tunnel	1107.2	1123.6		1126.3	1127.2	1127.4
I-90	1583	1557.6		1738.5	1745.1	1703.2
I-93	3733.9	3781.5		3964.3	4087.3	4174.8
systemwide	553.8	578.9		600.9	602.6	604.7
Total	6977.9	7041.6		7430	7562.2	7610.1
Misc.	28	28		27.8	27.8	27.8
Construction	7005.9	7069.6		7457.8	7590	7637.9
Mgmt Reserve	259.3	0		0	0	0
Total	7931.4	7741.4		8152.1	8283.1	8334

Figure 6 shows the bar graphs of the variances, i.e., the deviation of forecast from the budget, for the three groups of cost items: Design/construction/reserve; construction cost by segments; and project direct and support costs. The first two groups of variances are derived from Table 5-2 and the last group is derived from data in Table 5-1.

Figure 4


Cost Variance Summary: Forecast - Jun 96 Budget
Jun-96
Jan-97
Feb-97
Mar-97
Variance, $M
800
600
400
200
0
-200
-400
Final Design
Construction
Mgmt Reserve
Total
Tunnel
I-90
I-93
systemwide
Total
Direct
Support
Total
Design/Construction/Reserve
Construction
Project

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In the course of this study, the Project Team spoke with many individuals. With some, the contact was brief; with others, it was a long, face-to-face interview. To all these individuals our appreciation for their generosity with time, information and insights.

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